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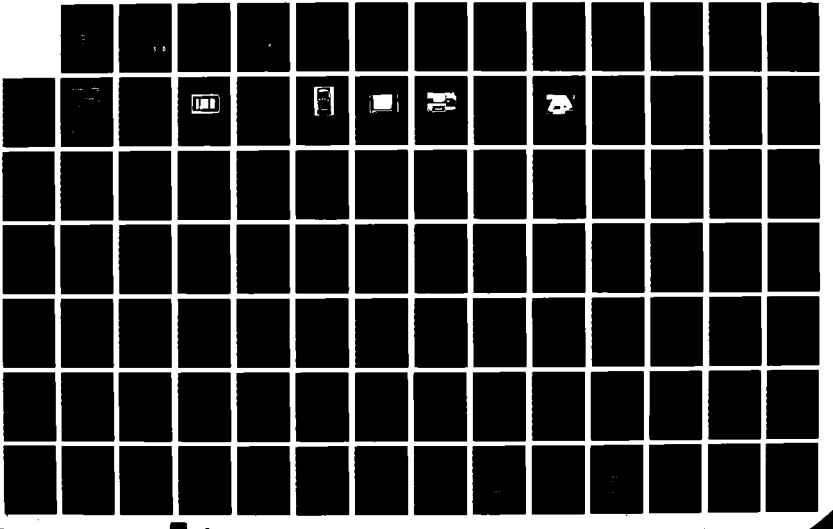

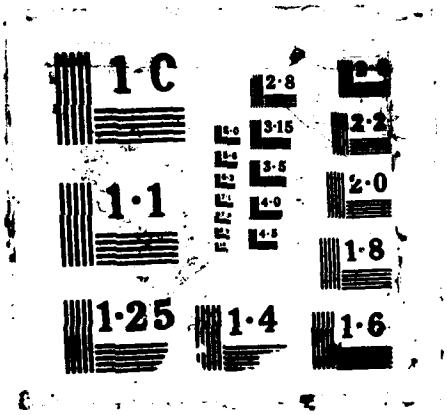
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AN EXPERIMENTAL STUDY OF A SIX KEY HANDPRINT CHORD KEYBOARD

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May 1986

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This study compared a production chord keypad and a 4x4 numeric keypad for numeric and alphabetic character entry. Of primary interest was the measure of character entry speed gained on each keypad over five days with one half hour practice each day. Results show that within the time constraints of the study, neither keypad was superior in terms of speed. Proficiency level gained was compared to the 50% level of average speed demonstrated on the beginning QWERTY typing test. This level was not gained, but the 25% level was reached under all three conditions: numeric keypad with no memory aids and chord

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keypad with and without memory aids. Use of Mnemonic memory aids increased the number of errors made on the chord keyboard. The 4x4 keypad was found to have significantly less errors than the chord keyboard.

AN EXPERIMENTAL STUDY OF A SIX KEY HANDPRINT CHORD KEYBOARD

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The views, opinions, and/or findings contained in this report are those of the authors, and should not be construed as an official Department of the Army position, policy, or decision unless so designated by other documentation.

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INTRODUCTION

Chord keyboards are data entry keyboards which use the simultaneous activation of two or more keys to input alphanumeric characters. Although not new, these types of devices have been the subject of both popular and industrial interests as data entry devices for the non-typist. The original interest in chording keyboards dates back to the late fifties and early sixties. These early devices had keys ranging in number from 4 to 12. Operation was ordinarily two handed. Of these early mechanisms, the court reporter's steno-writing system is best known.

The set of possible chords with only 7 keys (the summation of combination of 7 keys taken 'n' at a time (n=1,2,3,4,5) is equal to 127) is larger than the set of keys available on standard keyboards. The extra chords are then used for special characters, operator assignable functions, syllables or even entire words or phrases. The Velotype is just such a device (Special Systems Industry, no date). With 37 keys on the board, both hands are used. The keys are arranged in three groups. The left side has the initial consonants, the right side is almost a mirror image of the left and is dedicated to final consonants, vowels are in the middle (see Figure 1). The lesser used letters do not have dedicated keys but are instead generated by a two-key chord (e.g. T+J=D). With this layout, a three letter syllable can be spelled out with a three-key chord.

Some studies were cited in the sales literature for the Velotype, such as an undocumented study by the Dutch Association for Stenography and Office Practices. No quantitative results were reported but the conclusions they felt justified in making were:

1. The typing speed inexperienced velotypists can reach is three times as high as the speed of an experienced typist.
2. The speed of an experienced velotypist is approximately 900 to 1000 strokes per minute. This is faster than normal speech (bold face theirs) The speed of an experienced typist is between 250 and 300 strokes per minute.
3. Learning to velotype takes only 25% of the time it takes for traditional typing in order to reach the same average typing speed.

No other performance or learning studies are listed.

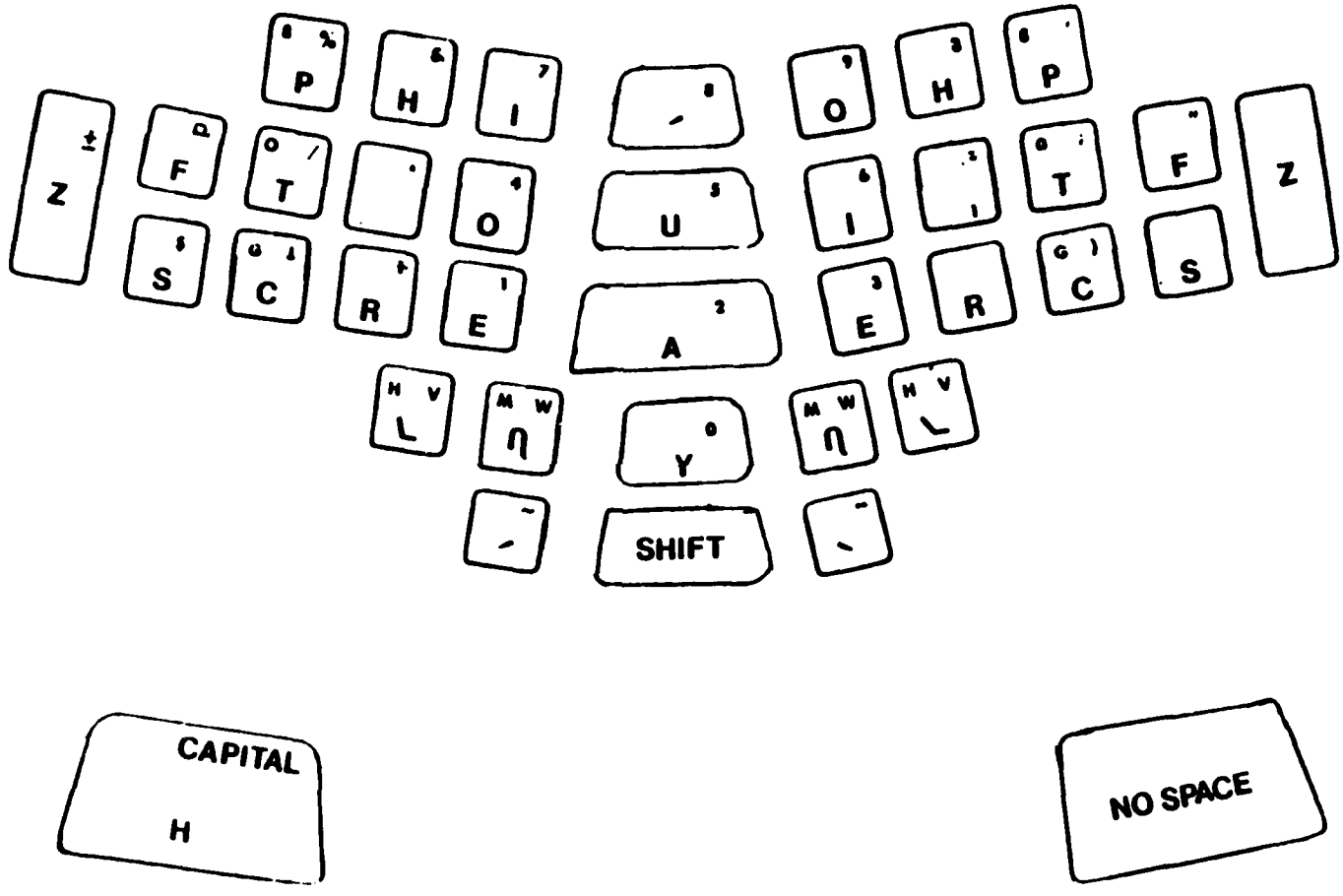


FIGURE 1

Velotype keyboard

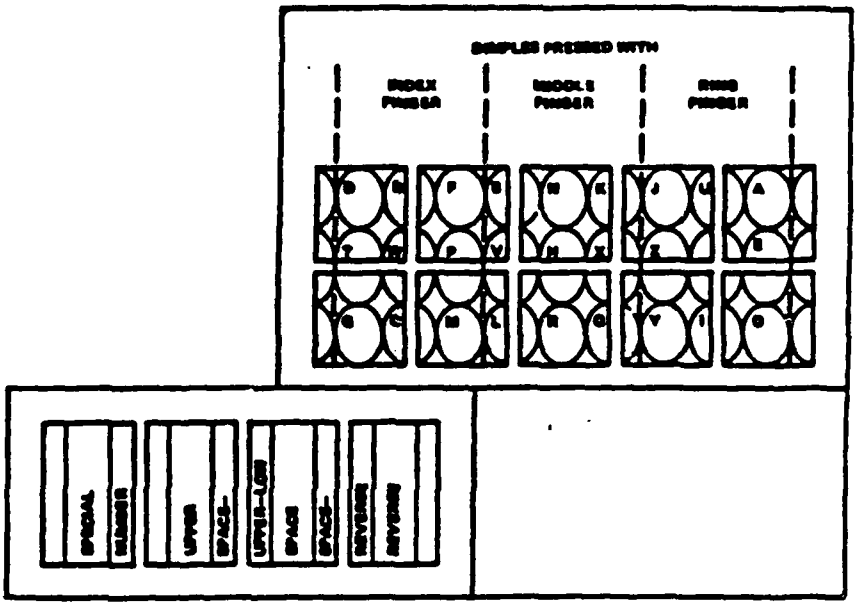
During the 1970's Nathaniel Rochester and Frank Bequaert developed another device with several keys per finger (Rochester, et al 1977). Their device had a five by two array of keys with a row of four rectangular thumb keys (see Figure 2). With the letters plotted on the corners, the keys utilized a swivel type activation. The designers claim 4407 possible chords, using only the thumb and the three strongest fingers of one hand.

Generally, there is a smaller number of keys present on a chord keyboard than on a standard keyboard. Each key is used several times in different combinations to produce various characters. This aspect of chording allows fewer keys to produce the same character set and this in turn, allows the board to be smaller than conventional keyboards. The smaller size enables these keyboards to be placed where other keyboards cannot be used. Also with fewer keys, many can be operated with one hand. These two features eliminate the need for the board to be immediately in front of the operator. This gives rise to unique applications such as operation within a cockpit of aircraft, conceivably under acceleration conditions. There is improvement of less novel workstations since the uncomfortable and stressful position common to typing is eliminated, thereby improving the ergonomic acceptability of the keying task.

A "handprint" keyboard is at the opposite extreme from full keyboards because it has the same number of keys as the number of fingers used to operate it, with perhaps one or two extra keys which are used infrequently. With so few keys, there is no motion of the fingers other than for key press; the keys are arranged to allow the fingers to rest naturally above them.

In their report, Alden and his associates state there is supporting data for "the hypothesis that keyboards which tend to minimize the number or the distance of finger-reaching movements are capable of the fastest operation, particularly for special purpose tasks" (Alden, Daniels, and Kanarick, 1972). Klemmer ((1958) as reported in Seibel (1972)) trained two subjects on a two-handed handprint keyboard where the various characters were represented with two key chords. He reported that entry speeds were not "out of line with performance in learning to type on a conventional machine." This early work is reported by Seibel to be the beginning of the investigation of chord keyboards.

Ratz and Ritchie ((1961) as reported in Alden et al (1972)) performed a study to rank the 31 chords that are possible with one-hand. They ranked them with respect to speed: motor constraints (not decision time) as the limiting factor. In a replication of the Ratz and Ritchie study, Seibel (1972) reports very similar times for the 31 chords, and that continuous improvement in discriminative chord reaction time occurred over 30 days. Following this train of investigation, Seibel reports that "...if the effect of motor difficulty is balanced out, the number of alternative chords involved in a given reaction time task makes little or no difference in the reaction time for numbers 5 through 31. The overall average motor difficulty of a set of responses, however, does influence the reaction times for



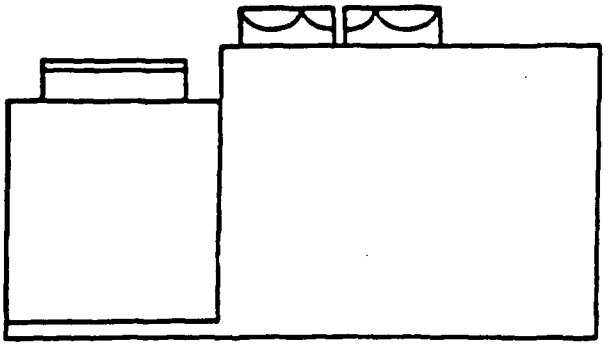


FIGURE 2

Rochester, Bequaert, and Sharp's Chord Keyboard

the specific chord responses in the set." (Seibel 1972). This effect is again mentioned in another study by Seibel in which reaction times for 1,023 alternatives are only approximately 25 msec. slower than the reaction times for 31 alternatives. Seibel concludes that "Part of this small difference is attributable to the fact that the larger set contained more difficult chord patterns."

Handprint keyboards designed for one hand operation have certain advantages over keyboards that require two hands. Without the necessity of reaching with both hands, the keyboard may be used in any position, not necessarily on a desk or flat surface in front of the operator. One hand operation and a compact size allow the machine to be used anywhere, on a chair arm, or mounted on the side of the chair near the thigh. It would also be possible to integrate the device in the control column of some types of vehicles, such as high performance aircraft.

The main argument against most types of nonconventional keyboards is that hunt-and-peck operation is not possible and is therefore not suitable for novice operators. However on a hand print keyboard, with a simple, straightforward method of chording and the proper cue card, this argument may not be valid. Mnemonics are used for example, on the Microwriter, a production chord keyboard by Microwriter ltd. Some are visual such as the "H" where the crossbar produced by the thumb and little finger is visualized. Others are symbolic, like the "O" which represents the bulls-eye which relates to the center of the hand, the middle finger. The third type of mnemonic is based on wordplay. The "S" is produced by the "S"ignet ring finger (see Figure 3). Rodwell (1980) reports that it took him approximately 30 minutes to learn the alphabet, 30 minutes for numbers and punctuation. Two hours per day for two weeks allowed him to build up to a reasonable speed. While this information is reported in a popular magazine and is anecdotal in nature, it gives an indication that the novice user can use such a device with relatively little experience.

In their study, Lockhead and Klemmer (1959) had operators learning 137 chord patterns in less than 23 hours. These chords however, were not on a handprint keyboard and were also for 100 common words as well as the alphanumeric characters. The learning was without any memory aids. Gopher and Koenig (1983) conducted an experiment using two 5-key handprint keyboards together, one for each hand. Each keyboard was independent from the other and could produce the entire character set. Their objective was to study the best coding scheme to represent identical letters for both hands. The first session was spent in memorizing the codes. No mnemonic is reported, memorization was up to the individual, but all individuals had memorized the codes in 35-40 minutes. Six more sessions at 1.5 hours each were scheduled. By the end of those sessions, no asymptote to speed had yet been encountered.

However, Gopher and Koenig did conclude that:

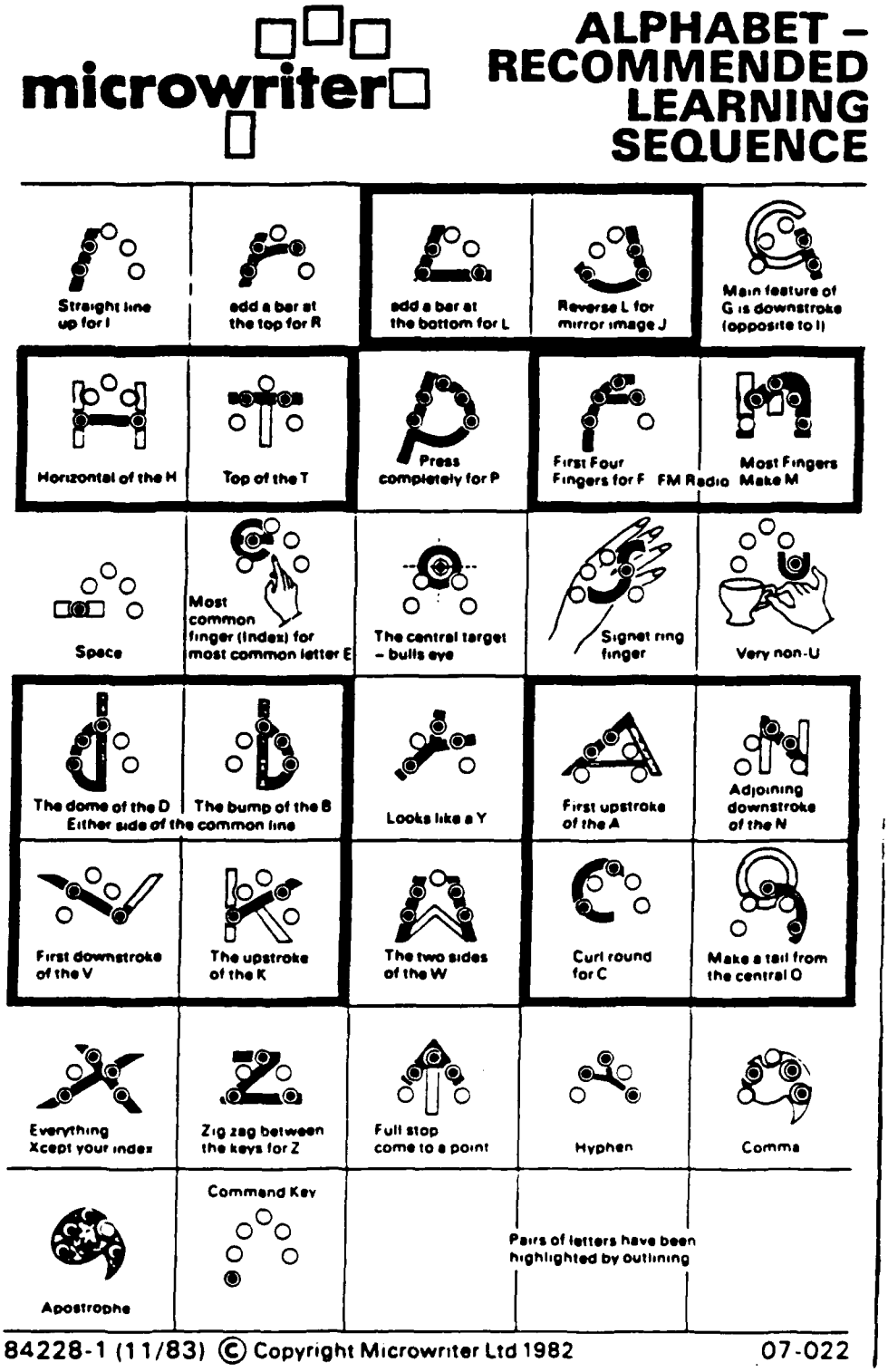


FIGURE 3

Microwriter Memory Aids

> "In light of the fundamental differences between the two typing keyboards in their skill components, one can conclude that it appears to be easier for humans to commit 52 chords to memory and activate them upon request, than to learn the ways of the hand to a similar number of keys spread out on a typing keyboard."

The study performed by Gopher and Koenig raises questions about the effectiveness of mnemonics for learning chords.

This study addressed the issue of task acquisition and the usefulness of mnemonics in learning the various chords and eliminating errors. Both conditions of chord learning, with or without mnemonics, were compared to the performance on the 4X4 keypad.

For the 4X4 keypad condition, the alphabetic keying method used was that described by Stealey (1985) to be the most efficient of those tested in that study. This is the method of pressing the key with the desired letter and then specify which of the three letters on that key is correct by pressing the key which specifies the letter position; left, center, or right. For example, if the letter "M" was desired, the "6" key was pressed and then the left arrow key (see Figure 4).

Study Objectives

The objectives of this study are summarized as follows:

1. Determine which of the keypads, Microwriter or the 4X4 keypad, gives the best performance with limited amounts of training and practice.
2. Determine if the use of mnemonics for chord keypad training leads to a reduction in the number of errors or if the absence of these mnemonics leads to confusion among different chords.
3. Determine the length of time to gain a set level of proficiency of alphanumeric entry on the chord keyboard and on the 4X4 keypad. As an arbitrary level, 50% of the average speed on the beginning QWERTY typing test will be used. Failing to attain that level, the proficiency level on the keypads will be calculated to the nearest 5% of the QWERTY test.
4. Determine if practice on the 4X4 keypad will affect entry rate on the 4X4 keypad.

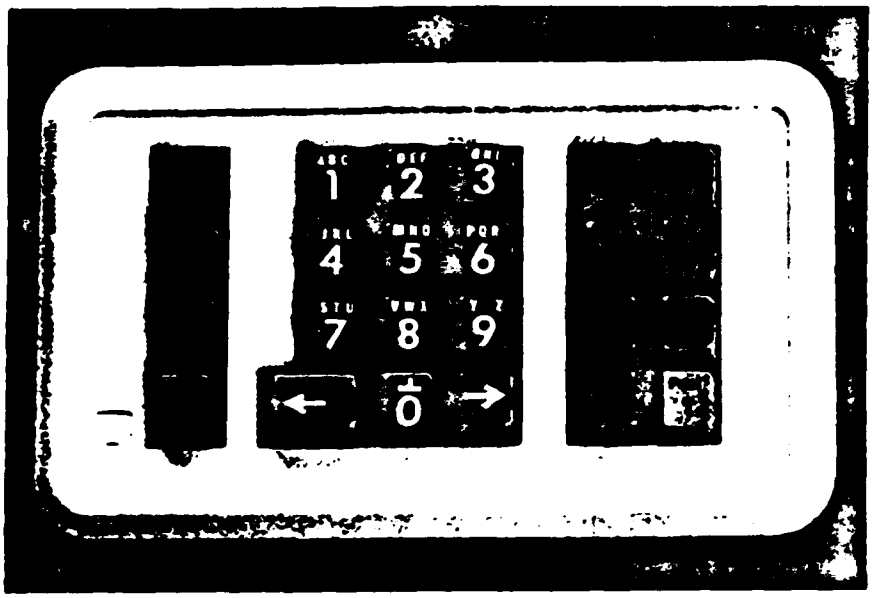


FIGURE 4

4X4 Keypad

METHOD

Research Participants

A total of 15 research participants (10 female, 5 male) participated in this study. The mean age of all research participants was 22.7 years. The range was 20 to 29 years. All of the research participants were students at Texas A&M University; 10 of them were undergraduates, the remainder were graduate students. Average amount of education was 16.5 years with all graduate students seeking a Masters degree. All research participants volunteered their time. Research participants were categorized into one of three typing skill levels (high, medium, and low skill typists), according to their performance on an initial 5 minute typing test taken from a standard typing text (see Appendix A).

Equipment and Facilities

The study was based on the only commercially available six key handprint keyboard, the Microwriter from Microwriter USA Ltd. It is a book-size device with approximately four pages of memory and a 15 character liquid crystal display (see Figure 5). For a full description and critique refer to Freff (1984). The display on the Microwriter was covered by opaque tape so all research participants would use the Apple monitor described below. The Microwriter, which produces standard ASCII output was interfaced to an Apple IIe microcomputer via a standard communications card.

The Apple accessory numeric keypad was used for the 4X4 keypad. The legends on the keys were covered by a dark covering and new numbers and letters, in white, were inscribed on top. This was necessary so that the keypad which is calculator format, that is "7 8 9" on the top row, could be used in phone format which has "1 2 3" on the top row. Also the letters were labeled on the proper keys as well as the directional arrows (see Figure 4). Software was used to allow the computer to translate the keypad's signals (see Appendix B).

The microcomputer collected speed and error rate information from both the keypad and the Microwriter. Applied Engineering's Timemaster II H.O. clock card was used to gather the time data for all conditions (see Appendix B for all programs used). Apple's standard 304.8 mm (12 inch) monochrome monitor served as the display for all conditions (see Figure 6). Another monitor was used for the experimenter's station (see Figure 7).

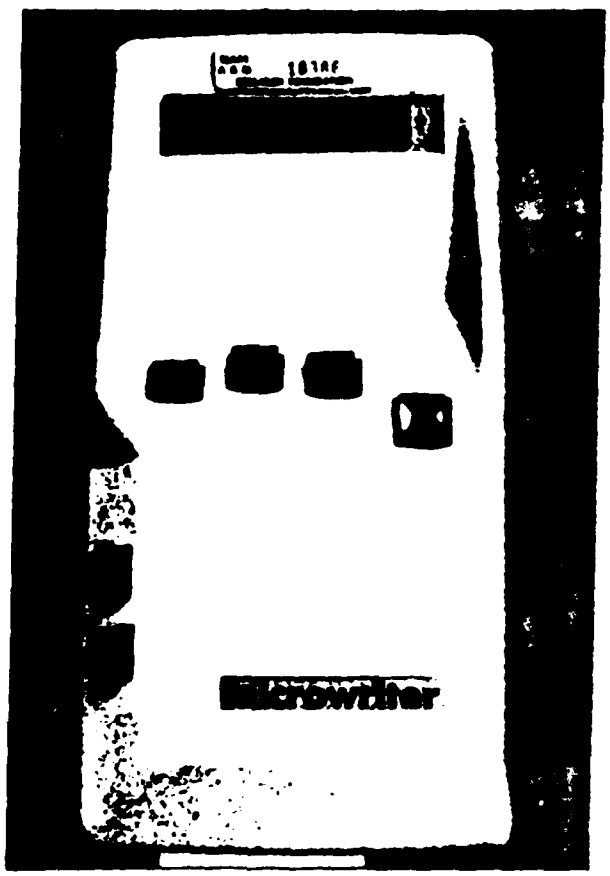


FIGURE 5

Microwriter Keyboard

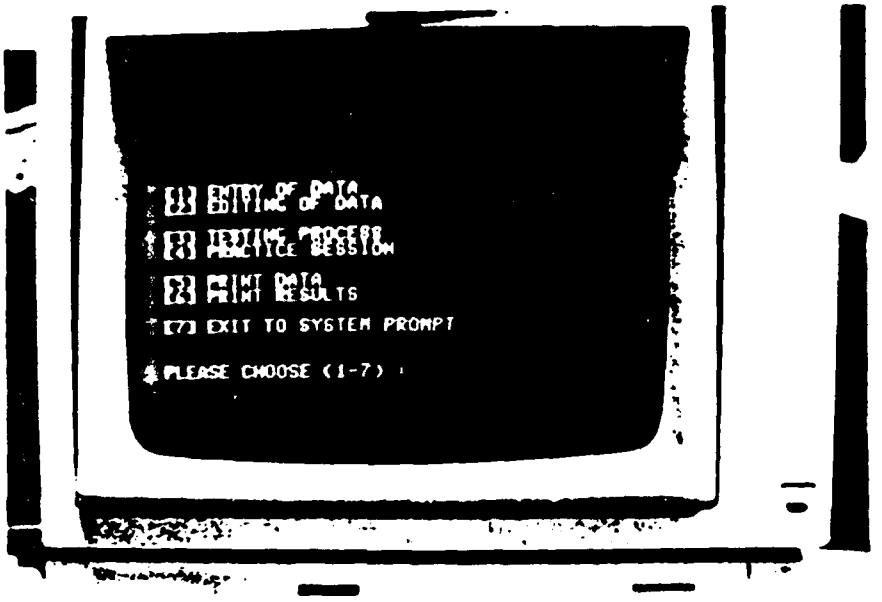


FIGURE 6

Standard Apple IIe Monochrome Monitor with Menu on Screer

FIGURE 7

Experimenter's Workstation

Procedure

Each research participant was required to read and sign an informed consent form. This document specified the nature of the study and advised the research participant that he or she was free to withdraw from the study at any time for any reason, without bias (see Appendix C).

The initial task performed at the first session was a standardized timed typing test to determine skill on a standard typewriter. This skill level was only used in the assignment to groups, and was not used in the analysis. An IBM Selectric was used. The assignment of research participants to groups was based on the test. A balance of three of medium skill and one each of low and high skill was assigned to each group.

For the chord keyboard groups, training material was similar to the documentation which comes with the Microwriter, but was reprinted and rearranged to eliminate information unnecessary to the experiment and tailored for the two conditions (see Appendices D and E). Also included in the materials for the Microwriter condition were one-sheet cue cards. The cue cards for each condition were equivalent in format, the only difference being that the memory aids were drawn in for the mnemonic condition operators. Appendix F has copies of both cue cards. For the 4X1 group the training material consisted of one sheet explaining the method of keying (see Appendix G).

There was a one hour period scheduled for each research participant each day for a duration of five consecutive days. At the beginning of the first session was the typing test following the completion of the informed consent form, and a demographic sheet. Then after assignment to a group, the research participant was given the training materials appropriate to the condition assigned. The keyboard used by the research participant could be repositioned as needed. All that was in front of the research participant was the keyboard being used, the Apple monitor, and any training material needed (see Figure 8). A 30 minute training and practice session followed. Training was self paced. A proficiency test was then given. All of the Microwriter research participants were able to become acquainted with all letters and numbers within the first session.

The test consisted of two runs of 25 sequences each. The first list was 25 "syllables" of four random letters. The second run was again 25 sequences, but of seven random numbers. These lists were presented on a single sheet of paper (see Figure 9). During the following days the sequences were not changed, but the order in which they were presented changed. This was to compensate for what learning might be possible for essentially meaningless

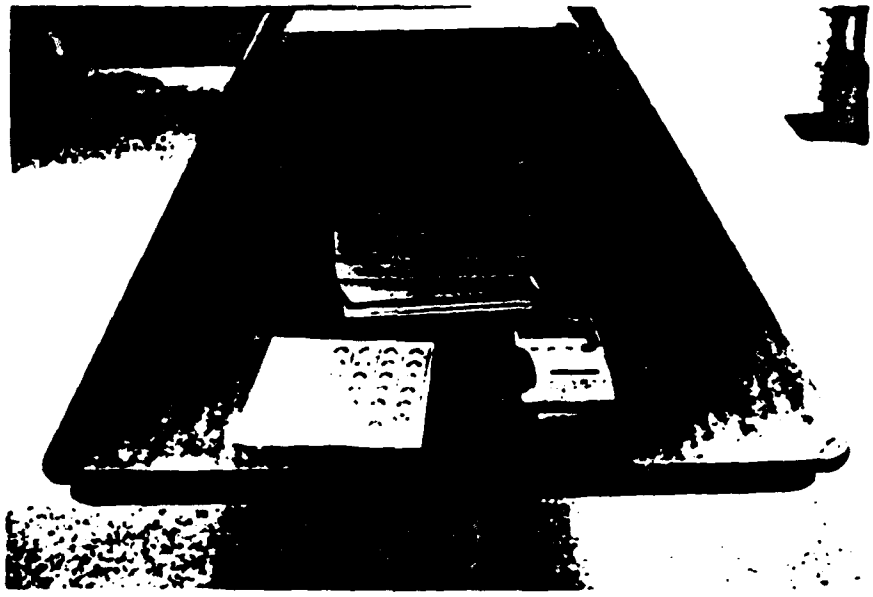


FIGURE 8

Operator's Workstation with Microwriter and Training Material

1. CFLD	1. 0215754
2. FFYN	2. 0554552
3. NQZV	3. 1487160
4. HFXW	4. 3847674
5. ZWXD	5. 9731261
6. RYOJ	6. 1174269
7. SLVD	7. 4336128
8. UZLM	8. 9380620
9. NKWS	9. 4954013
10. OVIW	10. 3676872
11. EFDN	11. 0709252
12. ZTNS	12. 4310015
13. FGLH	13. 6157006
14. ZAEN	14. 3135283
15. GSUI	15. 5704826
16. LMSB	16. 0924344
17. EOGM	17. 9795535
18. KGDH	18. 9375256
19. CDJO	19. 7262111
20. VSEB	20. 6102074
21. DJOY	21. 9780985
22. SEBC	22. 8916097
23. SNCP	23. 2596688
24. NYFR	24. 8144131
25. ZJBH	25. 1132254

FIGURE 9

Sequence Lists as Presented to Operators

material. The characters appeared on the screen as they were entered. No corrections were allowed and the screen cleared as soon as the sequence of four or seven characters was completed. The computer kept track of the sequence time, while total time to complete the list was tracked by stopwatch. Henceforth the term "sequence" will refer to individual groups of four letters or seven numbers. The term "list" will refer to the summary of the 25 sequences.

The computer also kept track of those alphanumeric characters missed on the test. The printout listed the number of incorrect characters entered in the sequence, what was entered, what should have been entered and the time it took to enter it (see Figure 10). This was done to give the research participant an easy comparison between an error and the correct response. The record for the alphabetic list was printed in another room as the research participant was being tested on the numeric list. When the numeric list test was completed, that record was printed out immediately and the entire page with the results of both runs was given to the research participant for review. The experimenter went over the list with the operator and pointed out the mistakes and had the research participant compare finger motions of what was erroneously entered and what was the correct character.

This testing and feedback was repeated every day after the 30 minute practice sessions. The practice sessions were spent typing in news articles which contained both numbers and letters (see Appendix H for example).

Experimental Design

The model for the study was repeated measures complete block design; condition by days with repeated measures over days. The independent variables in this experiment were condition, which was determined by the keyboard (4X4 keypad, chord keyboard with memory aids, and chord keyboard without memory aids); task (letters and numbers); days (1, 2, 3, 4, and 5); and research participants (1 through 15).

Dependent Variables

The dependent variables for this experiment were errors-per-list, sequence times, and list times. Sequence time is that interval between the keypress for the first and last letter or number in the sequence. The time was recorded in this way for all 25 sequences in the list. A digital stopwatch used to collect list times was activated manually by the experimenter. The time was started upon hearing the first keypress and stopped upon hearing the disk drive start on the computer which was, for all practical purposes, instantaneous with the final keypress of the last sequence.

```
CELIN.3LE
  8/28
  END

0                0                0                0                1
CPLD             PPKN             NQZU             HPXW             ZWXE
CPLD             PPKN             NQZU             HPXW             ZWXO
1.751 sec        1.577 sec        4.399 sec        3.608 sec        4.661 sec

0                0                0                0                0
RVOJ             SLUD             UZLM             NKWS             QUIW
RVOJ             SLUD             UZLM             NKWS             QUIW
2.29 sec         2.928 sec        3.046 sec        1.819 sec        2.82  sec

0                0                0                0                0
EFDN             ZTNS             FGMH             ZHEN             GSUJ
EFDN             ZTNS             FGMH             ZHEN             GSUJ
3.004 sec        1.618 sec        3.359 sec        2.256 sec        1.955 sec

0                0                0                0                0
LMSB             EQGM             KGUM             CDJO             USEE
LMSB             EQGM             KGUM             CDJO             USEE
3.459 sec        2.989 sec        2.013 sec        2.913 sec        2.883 sec

0                0                0                0                0
DJOK             SEBC             SNCF             NKFR             ZJBH
DJOK             SEBC             SNCF             NKFR             ZJBH
2.493 sec        2.374 sec        1.844 sec        2.921 sec        4.248 sec

-------------------------------------------------------------------------------

CELIN.3NE
  8/28
  END

0                0                0                0                0
0215754          0554555          1487160          3897674          9731281
0215754          0554555          1487160          3897674          9731281
4.614 sec        2.69 sec         3.556 sec        3.263 sec        3.179 sec

0                0                1                0                0
1174269          4336128          9380626          4954013          3676872
1174269          4336128          9380620          4954013          3676872
3.701 sec        3.5 sec          3.701 sec        3.751 sec        4.257 sec

0                0                0                0                0
0709252          4310015          6157006          3135283          5704686
0709252          4310015          6157006          3135283          5704686
3.499 sec        2.912 sec        2.93 sec         3.225 sec        3.585 sec

0                0                0                0                0
0924344          9795535          9375259          7262111          6102074
0924344          9795535          9375259          7262111          6102074
3.586 sec        3.469 sec        3.781 sec        2.922 sec        3.977 sec

0                0                0                0                0
9783985          8916097          2596688          8144331          1122254
9783985          8916097          2596688          8144331          1122254
4.964 sec        3.074 sec        3.208 sec        4.192 sec        3.208 sec
```

FIGURE 10

Sample Test Results

One error was counted for each character that was incorrect, or omitted, or if an extra character was entered. The program could not determine if a character was omitted or an extra one entered, therefore if the string was one character off, they were all counted wrong by the program. This was corrected when the errors were tabulated by hand; a determination was made as to what type of error had occurred.

RESULTS AND DISCUSSION

The data collected in the study was analyzed using a two way Analysis of Variance with repeated measures. Separate Analyses of Variance were run for each dependent variable: errors, sequence times, and list times. The model used for all Analyses of Variance were the same: conditions by days with repeated measures across days. Duncan's multiple range tests were performed for all main effects found significant by each Analysis of Variance.

Throughout this discussion, the 4X4 numeric keypad will be referred to as "the keypad." The conditions using the Microwriter with the original memory aids and without the aids will be referred to as "mnemonic" and "plain" respectively.

The research participants were randomly assigned to matched groups based on the skill level exhibited on the initial typing test. The categorization was three levels: high, medium, and low. The results of the test and the grouping can be seen in Table 1. The overall range for the typing test was 27.6 to 64.3 words per minute. Those typing above 40 words per minute were considered high skill, those typing below 30 words per minute were considered low skill. The operators whose scores fell between these boundaries were considered medium. The upper boundary reflects a natural break in the scores. The lower boundary was set rather arbitrarily by grouping the three lowest scores together. This grouping and balancing was done to control any tendency for experienced typists to do better on manual dexterity tasks than research participants inexperienced with conventional keyboards.

The discussion of the data gathered on the three dependent variables involved in the analysis: sequence time, list time, and errors, is better divided by group of tests, beginning or ending. This division forms a logical outline from which to discuss the results.

Mean Times for Sequences

Letters: The mean times for each keyboard per day are shown in Figure 11. The actual values for the means are listed in Table 2. Initial inspection shows that on the first day's test, mnemonic started with a slightly higher mean (5.83 sec.) than the other two conditions (5.53 for keypad, 5.34 for plain). By the second day the keypad had the highest mean and remained in the top position. The corresponding Analysis of Variance for the test (Table 3), shows that neither condition nor the interaction of condition and days is significant. Again, "days" shows up as being significant. The Duncan Multiple Range test in Table 4 lists days 2, 3, and 4 as being significantly different from each other, while days 4 and 5 are not.

TABLE 1

Results of Typing Test: Means and Standard Deviations (all figures in words per minute)

	MNEMONIC	PLAIN	KEYPAD
LOW	28.0 wpm	29.6 wpm	27.6 wpm
MEDIUM	31.5 36.8 33.3	38.4 37.3 39.6	31.6 38.4 38.6
HIGH	58.5	64.3	58.3
AVERAGE	37.62	41.84	38.90
STANDARD DEVIATION	12.10	13.15	11.81

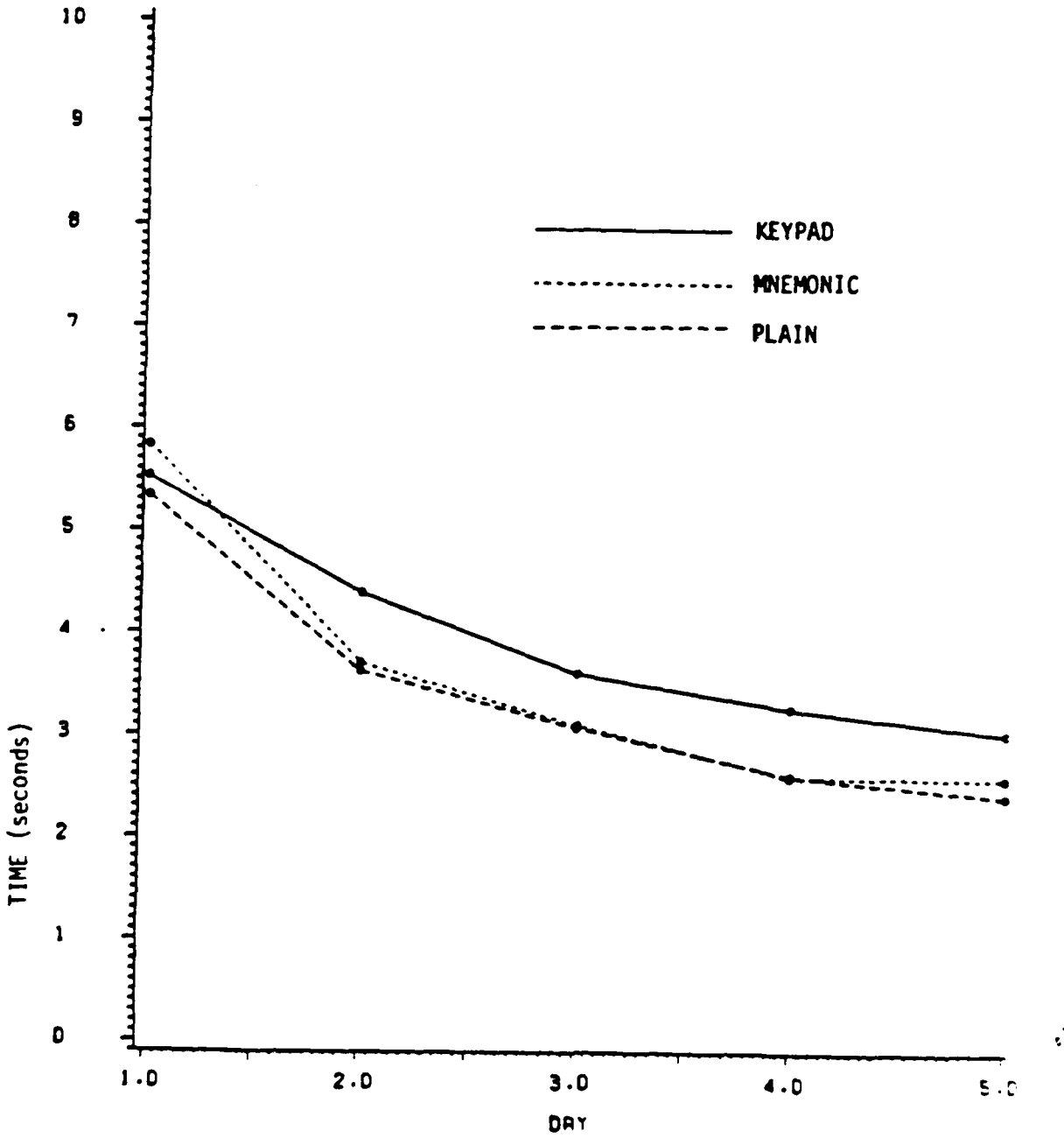


FIGURE 11

Mean Time by Condition Over Days for Letter Sequence Tests

TABLE 2

Means and Variances for Letter Sequence Times

		N	MEAN	VAR
CONDTI-ON	DAY			
KEYPAD	1	5	5.53	1.05
	2	5	4.39	0.73
	3	5	3.61	0.50
	4	5	3.27	0.26
	5	5	3.03	0.56
MNEMON	1	5	5.83	1.16
	2	5	3.71	0.88
	3	5	3.11	0.44
	4	5	2.59	0.18
	5	5	2.58	0.30
PLAIN	1	5	5.34	0.17
	2	5	3.63	0.38
	3	5	3.08	0.22
	4	5	2.61	0.26
	5	5	2.41	0.13
CONDTI-ON				
KEYPAD	ALL	25	3.97	1.37
MNEMON	ALL	25	3.56	2.01
PLAIN	ALL	25	3.41	1.34
	DAY			
ALL	1	15	5.57	0.72
	2	15	3.91	0.69
	DAY			
ALL	3	15	3.27	0.40
	4	15	2.82	0.31
	5	15	2.68	0.35
ALL	ALL	75	3.65	1.59

TABLE 3

Analysis of Variance for Letter Sequence Times

Source	df	MS	F	PR>F
Condition	2	2.0431	1.04	0.3842
Day	4	20.6819	190.64	0.0001 *
Condition x Day	8	0.2141	1.97	0.0704
Error Subject(Condition)	12	1.9702		
Error Subject*Day(Condition)	48	0.1085		
Total	74	1.5862		

* Significant at $p < 0.05$

Table 4

Duncan's Multiple Range Test for Comparison of Days for Letter Sequence Times

Alpha = 0.05 df = 48 MSE = 0.10849

Grouping	Mean	N	Days
A	5.5664	15	1
B	3.9069	15	2
B	3.2658	15	3
B	2.8249	15	4
B	2.6762	15	5

Numbers: In Figure 12 there are the mean times for each condition; actual values are listed in Table 5. The difference between conditions is significant at the 0.05 level. The table on page 35 has the Duncan Multiple Range test for condition and it shows that pairs: mnemonic and plain, plain and keypad, are not significantly different. Mnemonic and keypad are shown to be different. The difference between days in the Analysis of Variance (Table 6) is shown to be highly significant; the corresponding condition and day interaction is also calculated as being significant to the 0.0001 level. Table 8 shows the Duncan Multiple range test for days.

Mean Times for Lists

Letters: Figure 13 shows the means by condition over days. The actual values for each point in the graph are listed in Table 9. The corresponding Analysis of Variance in Table 10 gives the predictable significant difference for days, but shows no significance for conditions or the interaction of condition and day. The pertinent Duncan Multiple Range test for days is listed in Table 11. Note that although not significant, the times for day 5 were longer than for day 4.

Numbers: The means of the sequence times for the number test are arranged by condition over days in Figure 14; the actual values for each point can be found in Table 12. The Analysis of Variance (Table 13) shows the usual high significance between days to the 0.0001 level; it also shows the same level of significance for the condition-day interaction term. The Duncan Multiple Range test in Table 14 indicates no significant difference for days 3, 4, and 5.

Mean Errors

Letters: Figure 15 shows the trend of each condition over time. Keypad, obviously has the lowest error rate, starting with 2.40 error on the first day and finishing with 0.20 errors on the fifth. The complete list of actual values can be found in Table 15. The Analysis of Variance (Table 16) shows condition to be significant beyond the 0.05 level. Day is also significant. In the Duncan's Multiple Range test for condition (Table 17), it is further determined that only keypad is significantly different from the other two. The Duncan's Multiple Range test for days appears in Table 18 and shows that only day one is significantly different.

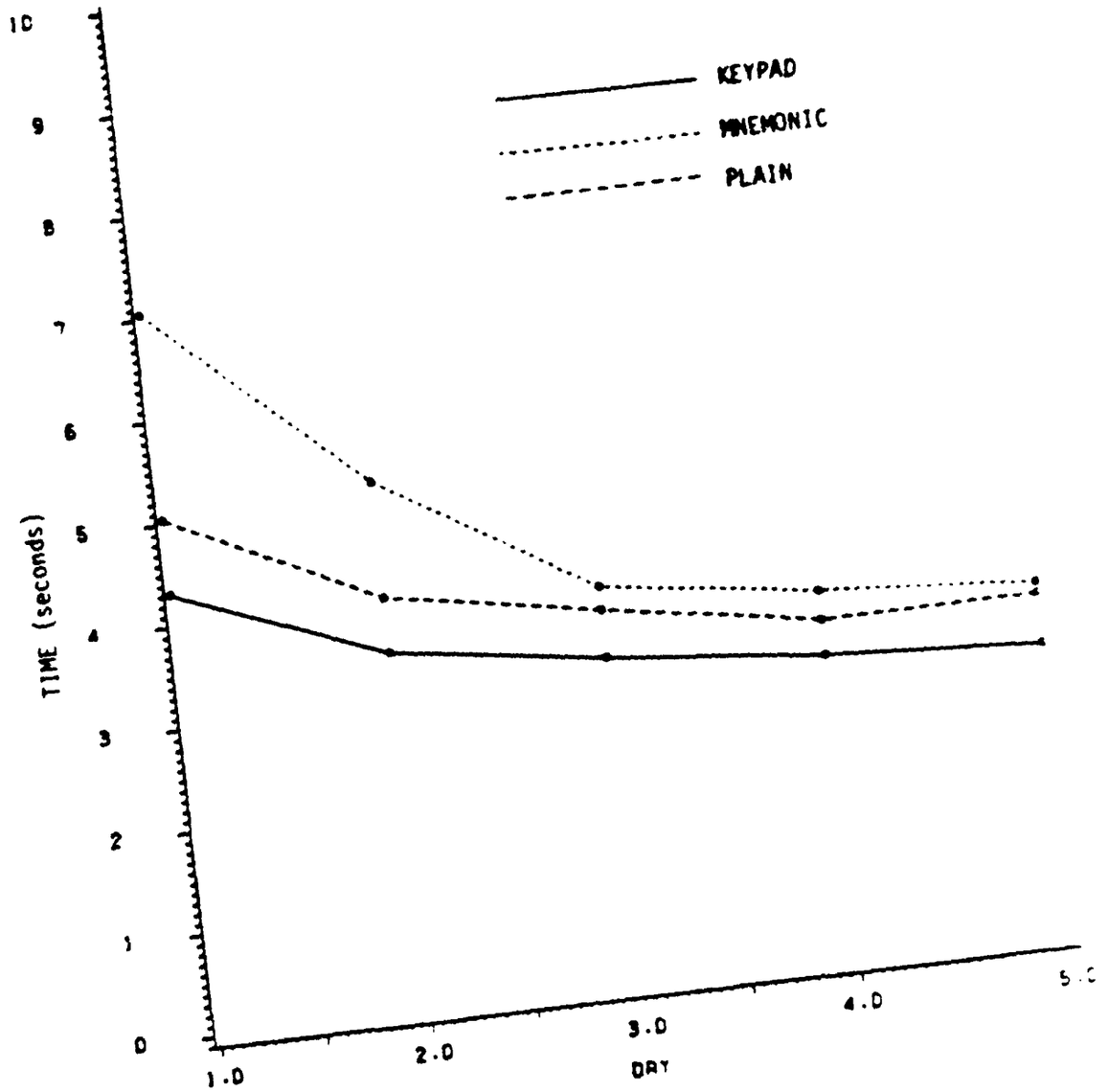


FIGURE 12

Mean Time by Condition Over Days for Number Sequence Tests

TABLE 5

Means and Variances for Number Sequence Times

		N	MEAN	VAR
CONDITION	DAY			
KEYPAD	1	5	4.31	1.76
	2	5	3.52	1.66
	3	5	3.23	1.31
	4	5	3.01	0.95
	5	5	2.88	1.19
MNEMON	1	5	7.05	1.18
	2	5	5.18	0.88
	3	5	3.91	0.21
	4	5	3.64	0.08
	5	5	3.48	0.08
PLAIN	1	5	5.04	0.11
	2	5	4.05	0.06
	3	5	3.68	0.17
	4	5	3.35	0.11
	5	5	3.37	0.07
CONDITION				
KEYPAD	ALL	25	3.39	1.42
MNEMON	ALL	25	4.65	2.27
PLAIN	ALL	25	3.90	0.49
	DAY			
ALL	1	15	5.47	2.31
	2	15	4.25	1.26
	DAY			
ALL	3	15	3.61	0.57
	4	15	3.33	0.40
	5	15	3.25	0.46
ALL	ALL	75	3.98	1.63

TABLE 6

Analysis of Variance for Number Sequence Times

Source	df	MS	F	PR>F
Condition	2	10.0846	4.00	0.046c *
Day	4	12.6910	66.31	0.0001 *
Condition x Day	8	1.2895	6.74	0.0001 *
Error Subject(Condition)	12	2.5240		
Error Subject*Day(Condition)	48	0.1914		
Total	74	1.6314		

* Significant at $p < 0.05$

Table 7

Duncan's Multiple Range Test for Comparison of Conditions for Number Sequence Times

Alpha = 0.05 df = 12 MSE = 2.52396

Grouping	Mean	N	Condition
A	4.6522	20	Mnemonic
B	3.9016	20	Plain
B	3.3894	20	Keypad

Table 8

Duncan's Multiple Range Test for Comparison of Days for Number Sequence Times

Alpha = 0.05 df = 48 MSE = 0.19138

Grouping	Mean	N	Days
A	5.4680	15	1
A	4.2502	15	2
B	3.6105	15	3
B	3.3304	15	4
B	3.2461	15	5

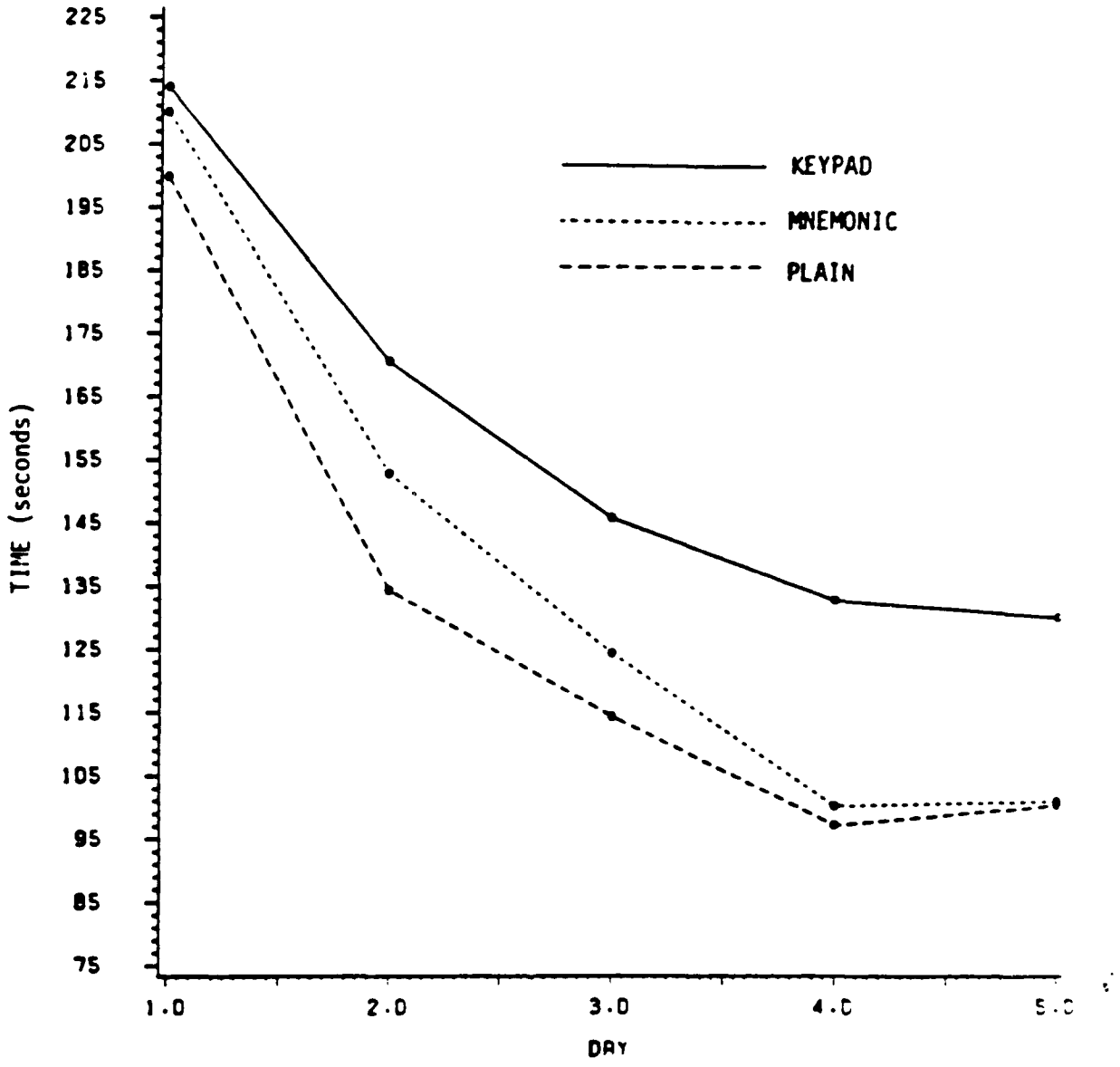


FIGURE 13

Mean Time by Condition Over Days for Letter List Tests

TABLE 9

Means and Variances for Letter List Times

		N	MEAN	VAR
CONDTI-ON	DAY			
KEYPAD	1	5	214.00	789.50
	2	5	170.60	924.30
	3	5	145.80	492.70
	4	5	132.80	29.70
	5	5	130.20	193.20
MNEMON	1	5	210.00	1042.5
	2	5	152.80	2486.2
	3	5	124.40	1036.8
	4	5	100.20	196.70
	5	5	101.00	340.50
PLAIN	1	5	199.80	170.70
	2	5	134.40	298.30
	3	5	114.40	358.80
	4	5	97.20	357.70
	5	5	100.40	149.30
CONDTI-ON				
KEYPAD	ALL	25	158.68	1415.1
MNEMON	ALL	25	137.68	2597.4
PLAIN	ALL	25	129.24	1698.3
	DAY			
ALL	1	15	207.93	610.50
	2	15	152.60	1293 7
	DAY			
ALL	3	15	128.20	723.31
	4	15	110.07	445.35
	5	15	110.53	402.41
ALL	ALL	75	141.87	2007 4

TABLE 10

Analysis of Variance for Letter List Times

Source	df	MS	F	PR>F
Condition	2	5745.6134	2.83	0.0982
Day	4	29474.453	107.63	0.0001 *
Condition x Day	8	211.8467	0.91	0.5140
Error Subject(Condition)	12	2027.4533		
Error Subject*Day(Condition)	48	232.0450		
Total	74	2007.4414		

* Significant at $p < 0.05$

Table 11

Duncan's Multiple Range Test for Comparison of Days for Letter List Times

Alpha = 0.05 df = 48 MSE = 232.045

Grouping	Mean	N	Days
A	207.93	15	1
B	152.60	15	2
C	128.20	15	3
D	110.53	15	5
D	110.07	15	4

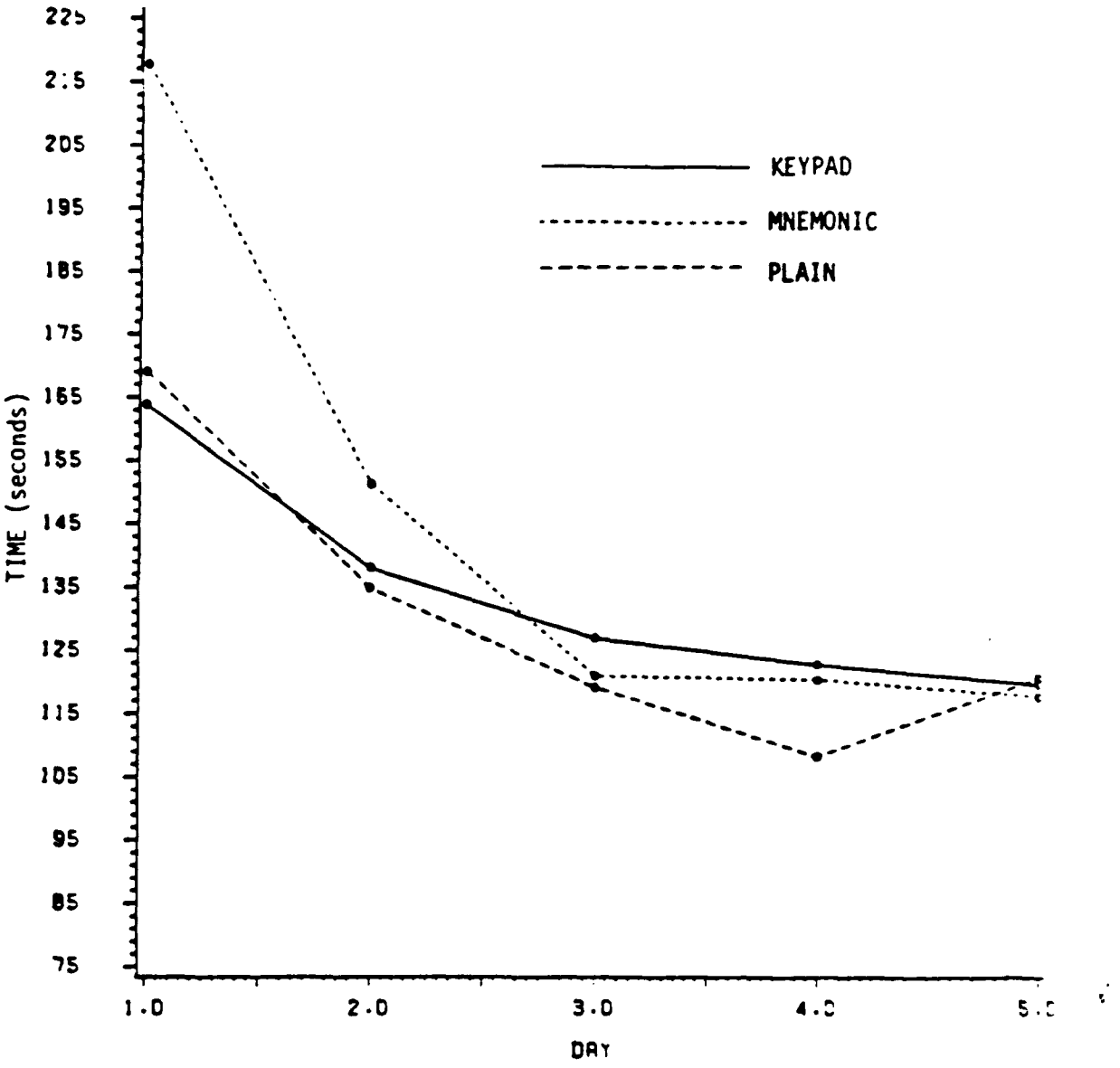


FIGURE 14

Mean Time by Condition Over Days for Number List Tests

TABLE 12

Means and Variances for Number List Times

		N	MEAN	VAR
CONDTI-ON	DAY			
KEYPAD	1	5	163.80	1152.2
	2	5	138.00	1164
	3	5	127.00	1272.5
	4	5	122.80	1018.7
	5	5	119.80	1171.7
MNEMON	1	5	217.60	591.30
	2	5	151.20	1033.2
	3	5	121.00	316.00
	4	5	120.40	94.80
	5	5	117.80	338.70
PLAIN	1	5	169.00	57.50
	2	5	134.80	47.20
	3	5	119.20	105.70
	4	5	108.20	65.20
	5	5	120.80	222.70
CONDTI-ON				
KEYPAD	ALL	25	134.28	1229.8
MNEMON	ALL	25	145.60	1901.6
PLAIN	ALL	25	130.40	545.50
	DAY			
ALL	1	15	183.47	1143.6
	2	15	141.33	695.24
	DAY			
ALL	3	15	122.40	405.97
	4	15	117.13	380.55
	5	15	119.47	496.84
ALL	ALL	75	136.76	1234.6

TABLE 13

Analysis of Variance for Number List Times

Source	df	MS	F	PR>F	
Condition	2	1559.6400	0.69	0.5197	
Day	4	11598.386	73.80	0.0001	*
Condition x Day	8	905.7367	5.76	0.0001	*
Error Subject(Condition)	12	2255.1200			
Error Subject*Day(Condition)	48	157.1700			
Total	74	1234.6443			

* Significant at $p < 0.05$

Table 14

Duncan's Multiple Range Test for Comparison of Days for Number List Times

Alpha = 0.05 df = 48 MSE = 157.17

Grouping	Mean	N	Days
A	183.47	15	1
B	141.33	15	2
C	122.40	15	3
C	119.47	15	4
C	117.13	15	5

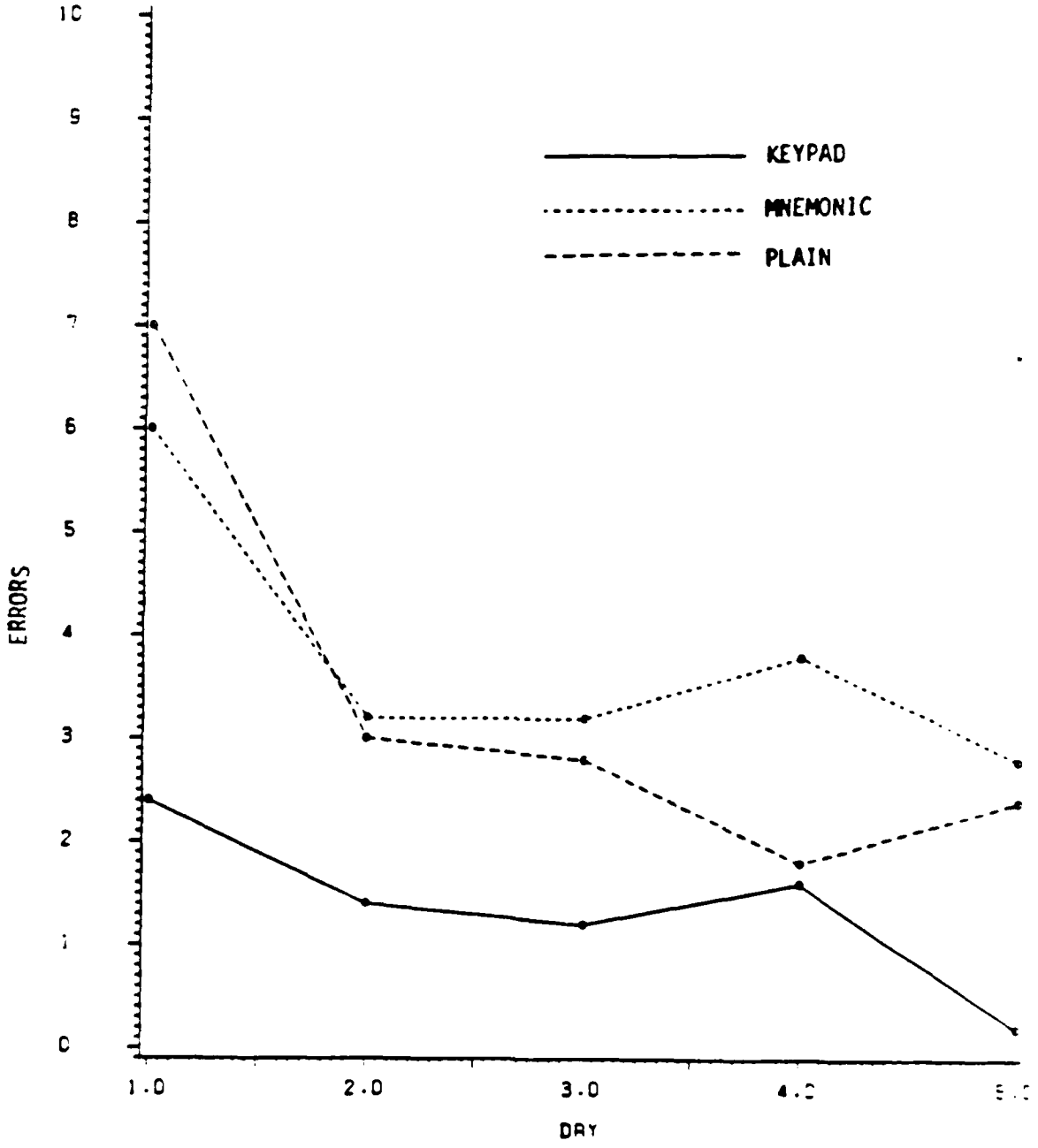


FIGURE 15

Mean Error by Condition Over Days for Letter Tests

TABLE 15

Means and Variances for Letter Error Count

		N	MEAN	VAR
CONDTI-ON	DAY			
KEYPAD	1	5	2.40	11.30
	2	5	1.40	2.80
	3	5	1.20	0.70
	4	5	1.60	0.80
	5	5	0.20	0.20
MNEMON	1	5	6.00	6.50
	2	5	3.20	3.70
	3	5	3.20	8.20
	4	5	3.80	28.70
	5	5	2.80	3.70
PLAIN	1	5	7.00	12.50
	2	5	3.00	8.50
	3	5	2.80	4.70
	4	5	1.80	0.70
	5	5	2.40	0.30
CONDTI-ON				
KEYPAD	ALL	25	1.36	3.16
MNEMON	ALL	25	3.80	9.83
PLAIN	ALL	25	3.40	8.00
	DAY			
ALL	1	15	5.13	12.84
	2	15	2.53	4.98
	DAY			
ALL	3	15	2.40	4.69
	4	15	2.40	9.69
	5	15	1.80	2.60
ALL	ALL	75	2.85	7.96

TABLE 16

Analysis of Variance for Letter Error Count

Source	df	MS	F	Pr>F
Condition	2	42.8133	3.95	0.0482 *
Day	4	25.5800	5.05	0.0018 *
Condition x Day	8	3.5300	0.70	0.6922
Error Subject(Condition)	12	10.8467		
Error Subject*Day(Condition)	48	5.0633		
Total	74	7.9647		

* Significant at $p < 0.05$

Table 17

Duncan's Multiple Range Test for Comparison of Conditions for Letter Error Count

Alpha = 0.05 df = 12 MSE = 10.8467

Grouping	Mean	N	Condition
A	3.8000	20	Mnemonic
A	3.4000	20	Plain
B	1.3600	20	Keypad

Table 18

Duncan's Multiple Range Test for Comparison of Days for Letter Error Count

Alpha = 0.05 df = 48 MSE = 5.06333

Grouping	Mean	N	Days
A	5.1333	15	1
B	2.5333	15	2
B	2.4000	15	4
B	2.4000	15	3
B	1.8000	15	5

Numbers: Figure 16 and Table 19 come from the data for the error count on the numbers test. The Analysis of Variance (Table 20) shows condition and day as significant and the interaction term approaching significance. The Duncan Multiple Range tests for conditions and days are listed in Table 21 and 22 respectively. Of note, but not statistically significant, is the fact that the days are not in the regular chronological order. Days 3, 4, and 5 are reversed but are not significantly different from one another.

Confusion Errors

Table 23 shows which letters were confused with other letters for the two chord keypad conditions. Since there were four letters in each sequence and 25 sequences in each list, a letter should occur an average of approximately four times in each list. The list was presented to the research participant five times meaning that the participant would have an opportunity to enter a particular letter 20 times over the course of the experiment. If a letter was put in place of another letter four or more times it appears in the table. This is an error rate of 20 percent or more. For example, the letter 'D' was entered in place of the letter 'C' more than four times by the subjects in the plain condition. As is shown by the chart only two letters appear in both conditions, those are the letter 'F' being entered instead of the letter 'D' and 'Z' instead of 'Q'.

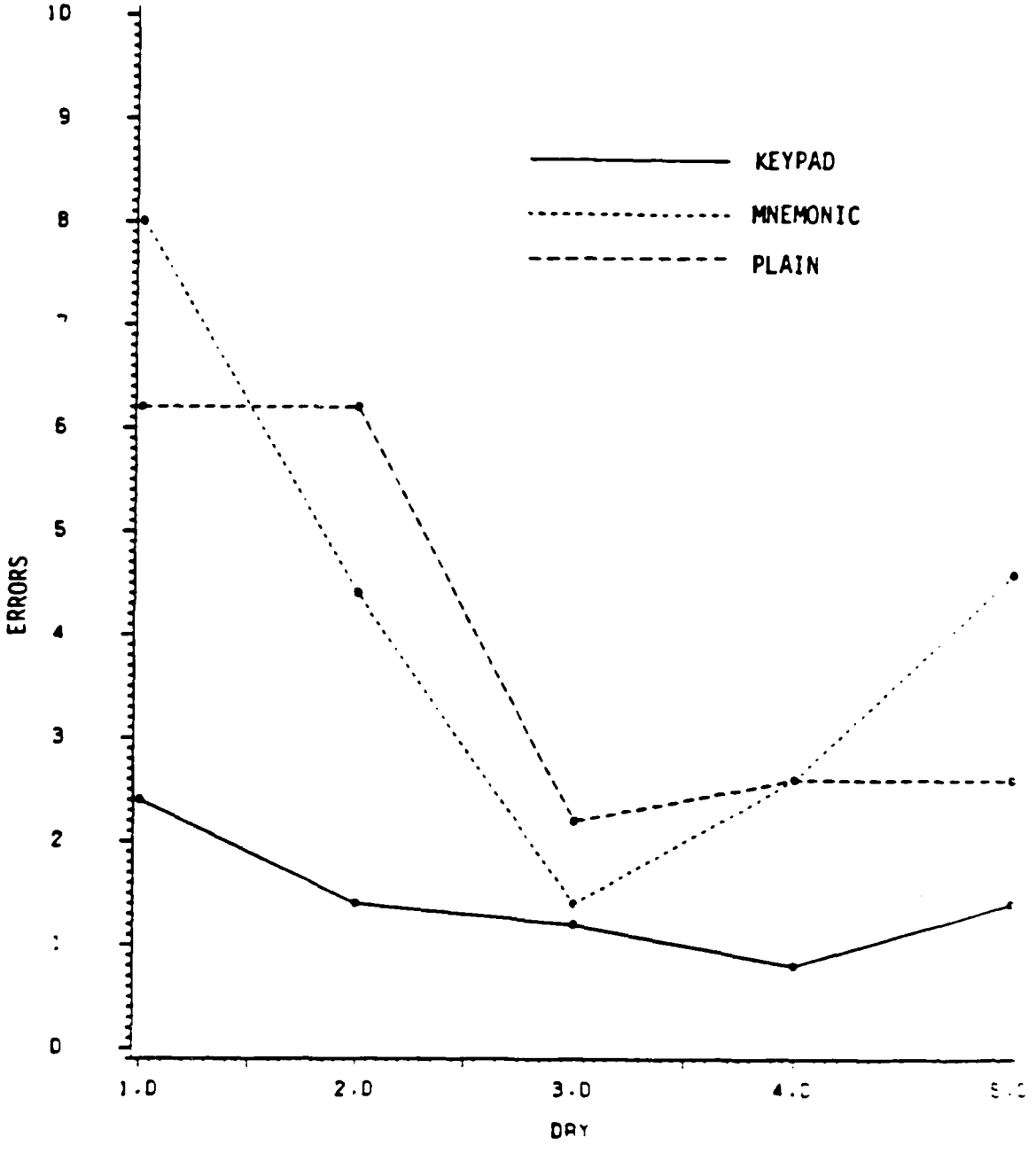


FIGURE 16

Mean Error by Condition Over Days for Number Tests

		N	MEAN	VAR
CONDTI-ON	DAY			
KEYPAD	1	5	2.40	5.30
	2	5	1.40	2.80
	3	5	1.20	0.20
	4	5	0.80	0.70
	5	5	1.40	1.30
MNEMON	1	5	8.00	16.50
	2	5	4.40	15.30
	3	5	1.40	2.30
	4	5	2.60	2.80
	5	5	4.60	4.80
PLAIN	1	5	6.20	8.20
	2	5	6.20	9.20
	3	5	2.20	1.20
	4	5	2.60	8.80
	5	5	2.60	0.80
CONDTI-ON				
KEYPAD	ALL	25	1.44	2.01
MNEMON	ALL	25	4.20	12.17
PLAIN	ALL	25	3.96	8.21
	DAY			
ALL	1	15	5.53	14.41
	2	15	4.00	12.00
	DAY			
ALL	3	15	1.60	1.26
	4	15	2.00	4.29
	5	15	2.87	3.84
ALL	ALL	75	3.20	8.84

TABLE 19

Means and Variances for Number Error Count

TABLE 20

Analysis of Variance for Number Error Count

Source	df	MS	F	PR>F
Condition	2	58.4400	5.59	0.0193 *
Day	4	38.2333	9.40	0.0001 *
Condition x Day	8	63.3867	1.95	0.0742
Error Subject(Condition)	12	10.4600		
Error Subject*Day(Condition)	48	4.0683		
Total	74	8.8378		

* Significant at $p < 0.05$

Table 21

Duncan's Multiple Range Test for Comparison of Conditions for Number Error Count

Alpha = 0.05 df = 12 MSE = 10.46

Grouping	Mean	N	Condition
A	4.2000	20	Mnemonic
A	3.9600	20	Plain
B	1.4400	20	Keypad

Table 22

Duncan's Multiple Range Test for Comparison of Days for Number Error Count

Alpha = 0.05 df = 48 MSE = 4.06833

Grouping	Mean	N	Days
A	5.5333	15	1
B	4.0000	15	2
B C	2.8667	15	5
C	2.0000	15	4
C	1.6000	15	3

TABLE 23

Confusion Matrix:
Matrix of letters which were entered more than four times incorrectly for a particular letter.

Correct entry	A	B	C	D	E	F	G
INCORRECT ENTRIES							
Mnemonic:				BF			
Plain:		M	O	FY			

Correct entry	H	I	J	K	L	M	N
INCORRECT ENTRIES							
Mnemonic:				J			
Plain:		L			R		Y

Correct entry	O	P	Q	R	S	T	U
INCORRECT ENTRIES							
Mnemonic:			VZ				
Plain:			Z				

Correct entry	V	W	X	Y	Z
INCORRECT ENTRIES					
Mnemonic:	LQ				
Plain:		P			

CONCLUSIONS AND RECOMMENDATIONS

To summarize, neither keypad, given the constraints of training and practice time, was found to be superior in terms of speed. The 4X4 keypad was however, found to have significantly less errors than the Microwriter. The second objective of the study dealt with the difference in errors due to the use or non-use of the memory aids. There was slight evidence to show that mnemonics increases the number of errors. Confusion between different letters occurred by the use or nonuse of the memory aids.

The third objective dealt with an arbitrarily set level of proficiency to be gained on the various keypads. This was set at 50% of the average speed demonstrated on the beginning QWERTY typing test. The average speed was calculated to be 39.45 words per minute or 197.25 characters per minute. The 50% level would therefore be 98.63. This level was not gained on any of the conditions. The 25% level, however, was attained by all conditions (see Table 24).

For the fourth objective of this study, it was found that slight practice on the 4X4 keypad does show improvement in performance, at least during the first four days. There was some evidence that a plateau of behavior was exhibited during the fifth day.

Given the short time each operator had in training (2.5 hours during five days) neither Microwriter or 4X4 keypad shows a really definite advantage in terms of speed. On the test for numbers, condition is shown to be significant beyond the 0.05 level (Table 6). Upon inspection of Figure 12 it can be seen that it is the mnemonic condition which caused the difference by having such relatively high times for the first two days. The difference is gone by the third day, the line converging with the rest. This convergence gives rise to the significant interaction term.

Figures 17 and 18 show the overall means by condition for sequence times. In these figures, it is apparent that there is very little difference in times. The keypad tends to show an enlarged difference in comparison to the conditions on the Microwriter when tested with numbers but it was still not significant. Figures 19 and 20 are bar charts showing the overall means by condition for list times. Again visible is the tendency (nonsignificant) for keypad to take longer for letters and shorter for numbers. This is not surprising since it takes two separate and distinct keypresses and even a visual search for the correct key in order to get one letter. It was expected that the keypad would take a much shorter time for keying because of the familiarization with the keyboard that all

TABLE 24

Data Entry Rates by Condition and by Type of Test

DATA ENTRY RATES (ALL FIGURES IN CHARACTERS PER MINUTE)

		SEQUENCE			LIST		
		BEGIN	END	AVERAGE	BEGIN	END	AVERAGE
KEYPAD	ALPHA	73.2	79.2	76.2	46.2	46.1	46.1
	NUMERIC	80.8	83.3	82.1	50.9	50.1	50.5
	AVERAGE	77.0	81.2	79.1	48.5	48.1	48.3
MNEMONIC	ALPHA	83.6	93.0	88.3	57.7	59.4	58.6
	NUMERIC	66.3	69.0	67.6	51.0	50.9	51.0
	AVERAGE	75.0	81.0	78.0	54.4	55.2	54.8
PLAIN	ALPHA	88.9	99.6	94.2	60.4	59.8	60.1
	NUMERIC	71.4	71.2	71.3	54.6	49.7	52.2
	AVERAGE	80.2	85.4	82.8	57.5	54.7	56.1

research participants had. Expectations were that the more familiar with the phone, the faster the person should be.

Where the keyboards differ greatly is in terms of errors. Condition is significant in both of the Analyses of Variance for error. In each (Tables 16 and 20), condition is significant to beyond the 0.05 level. The corresponding Duncan tests (Tables 17 and 21) register keypad differently than the other two conditions. The keypad had fewer errors at the end. It is of note that there is an absence of a significant interaction term in both, yet the relevant graphs, (Figures 15 and 16 respectively) show many changes in angle of the lines.

Looking at Figure 21 which has the overall error means by condition for letter tests it is seen that keypad has a smaller error rate than the other two. For the numbers tests, Figure 22 is of importance. In both analyses, the keypad was found to have significantly less errors than both of the Microwriter conditions.

For the confusion of letters for the chord keypad, only two letters appear in both conditions as being confused with the same letter four or more times in each condition. From this it is evident that the use or nonuse of the memory aids does lead to different errors.

All research participants were able to become familiar with all of the chords within the first session. The sequence time values of the first test given (when most chords were not learned and extensive use of the cue card was necessary) should give an indication of the difference in search time for the two conditions. Looking at the proper figures and tables (tests for the first day: Figures 11 and 12, and Tables 2 and 5), searching for the correct chord does not seem to be a problem for letters and only marginally for the numbers.

Entry rate on the keypad improved marginally over the duration of the study. As shown in the various interaction graphs (Figures 17 through 20) all keypad lines have a general downward trend. All Analyses of Variance dealing with time values have day as significant, although whether this is significant for just keypad is doubtful. A follow-up study readily suggests itself at this point.

Relying on these conclusions, chord keyboards of the handprint type tested here should not be used in applications which do not warrant long training times. Applications which cannot provide a large amount of training and which also have severe consequences for errors should not use a handprint chord keyboard. The 4X4 keypad should be used only in those situations which require infrequent and brief entry. It is possible that a 4x4 keypad could be used in a heads-up data entry task, but only after a long period of training. Further study is needed to ascertain how feasible this is, and whether other encoding methods would work better.

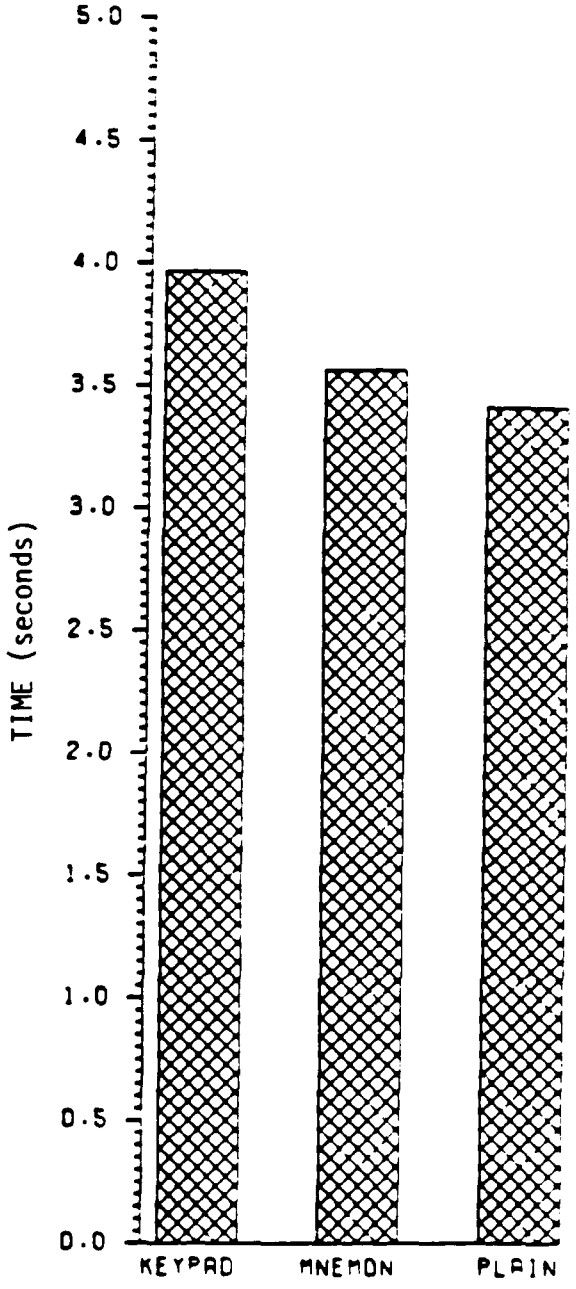


Figure 17
Comparison of Mean Sequence Encoding Times Between Conditions on Letter Tests

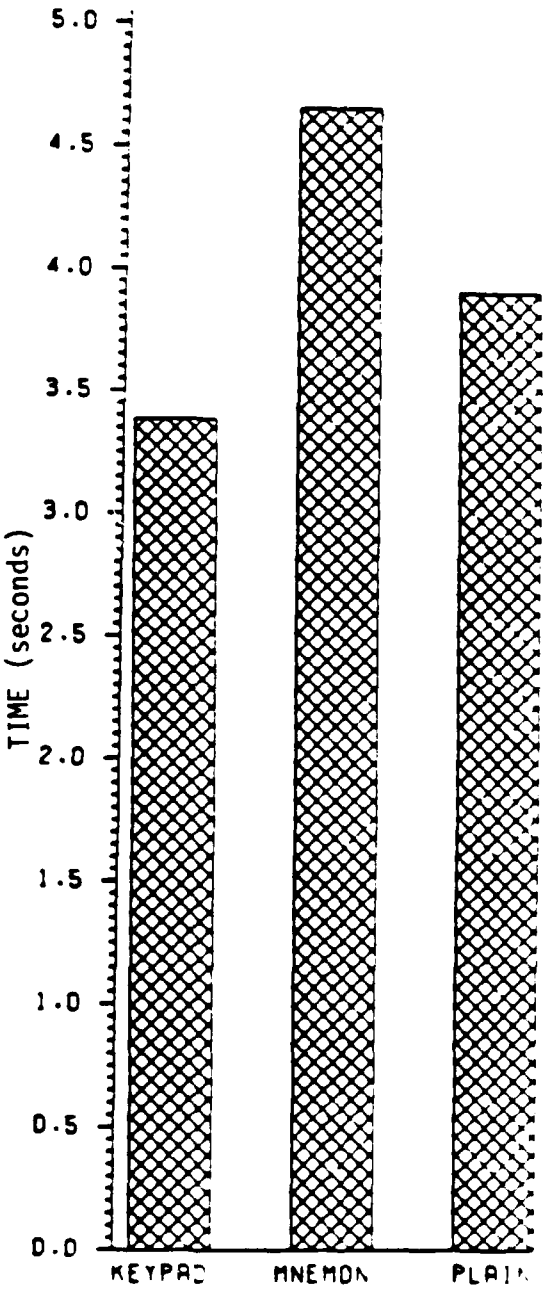


Figure 18

Comparison of Mean Sequence Encoding Times Between Conditions on Number Tests

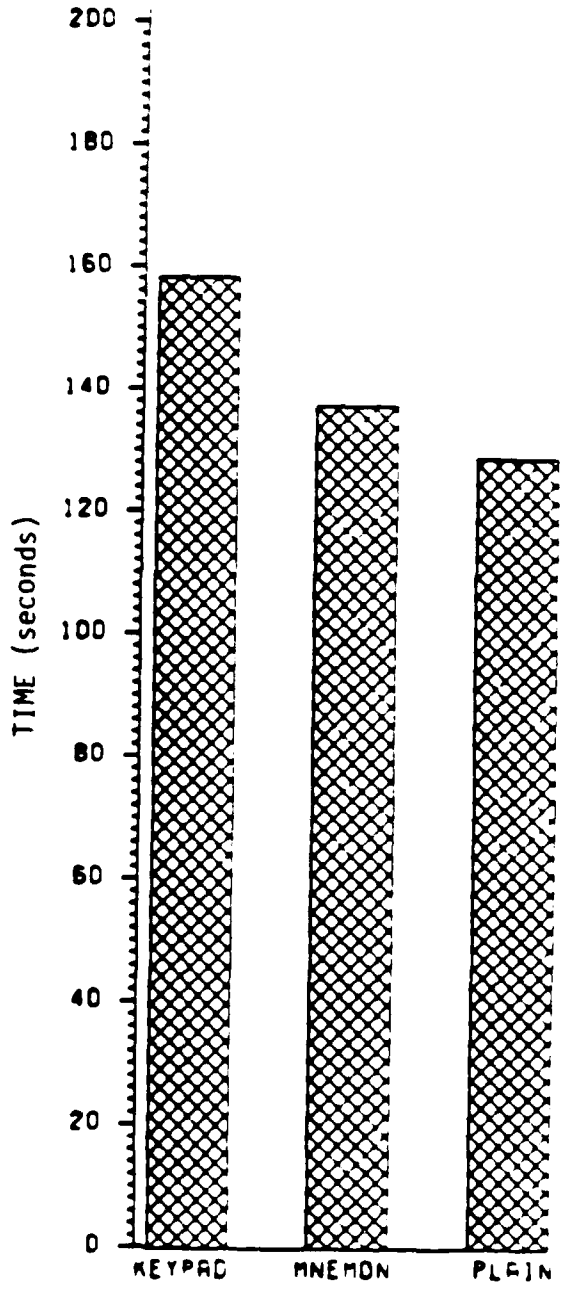


Figure 19
Comparison of Mean List Encoding Times Between Conditions on Letter Tests

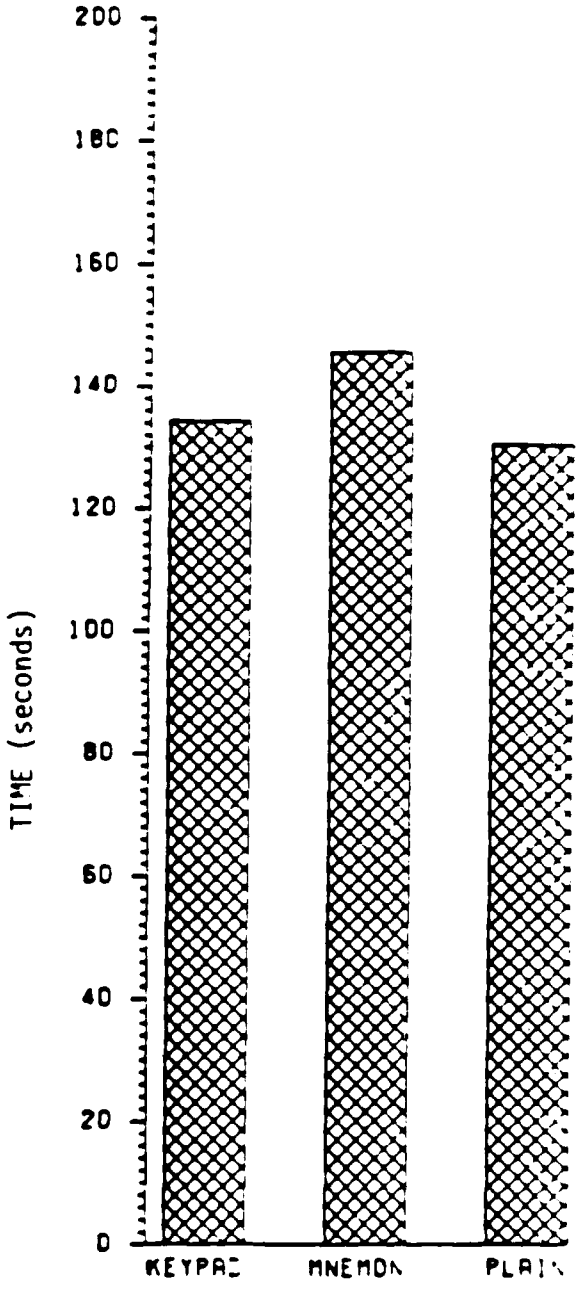


Figure 20
Comparison of Mean List Encoding Times Between Conditions on Number Tests

beyond the 0.05 level. The corresponding Duncan tests (Tables 17 and 21) register keypad differently than the other two conditions. The keypad had fewer errors at the end. It is of note that there is an absence of a significant interaction term in both, yet the relevant graphs, (Figures 15 and 16 respectively) show many changes in angle of the lines.

Looking at Figure 21 which has the overall error means by condition for letter tests it is seen that keypad has a smaller error rate than the other two. For the numbers tests, Figure 22 is of importance. In both analyses, the keypad was found to have significantly less errors than both of the Microwriter conditions.

For the confusion of letters for the chord keypad, only two letters appear in both conditions as being confused with the same letter four or more times in each condition. From this it is evident that the use or nonuse of the memory aids does lead to different errors.

All research participants were able to become familiar with all of the chords witnin the first session. The sequence time values of the first test given (when most chords were not learned and extensive use of the cue card was necessary) should give an indication of the difference in search time for the two conditions. Looking at the proper figures and tables (tests for the first day: Figures 11 and 12, and Tables 2 and 5), searching for the correct chord does not seem to be a problem for letters and only marginally for the numbers.

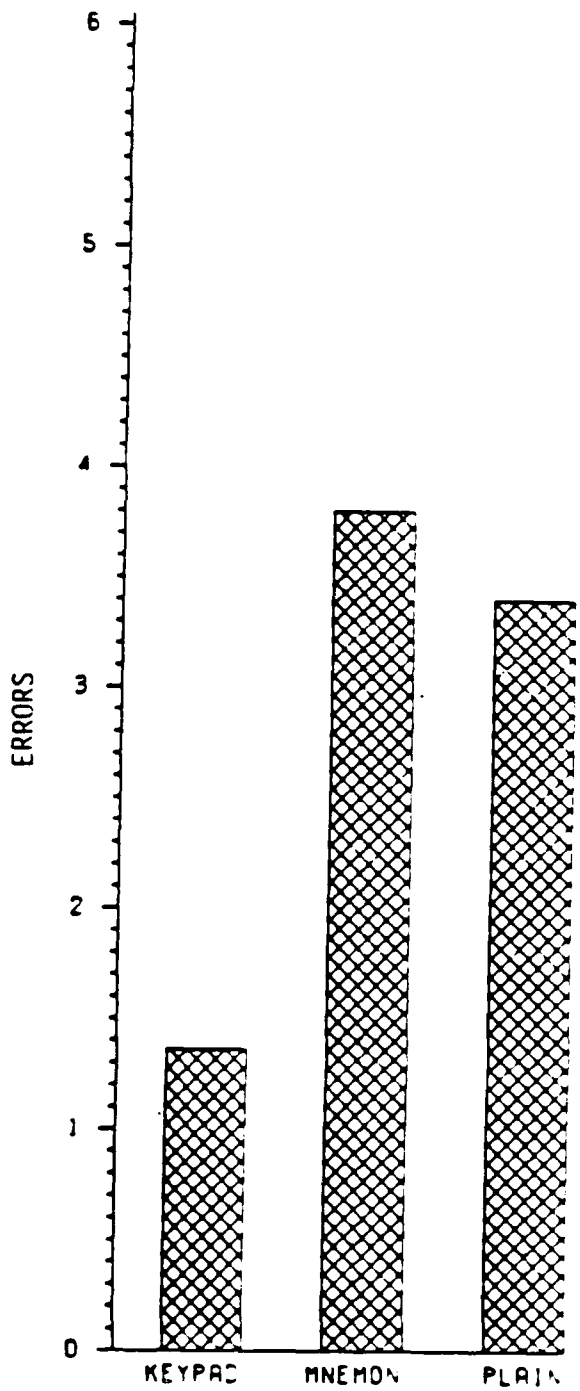


Figure 21
Comparison of Mean Errors Between Conditions
on Letter Tests

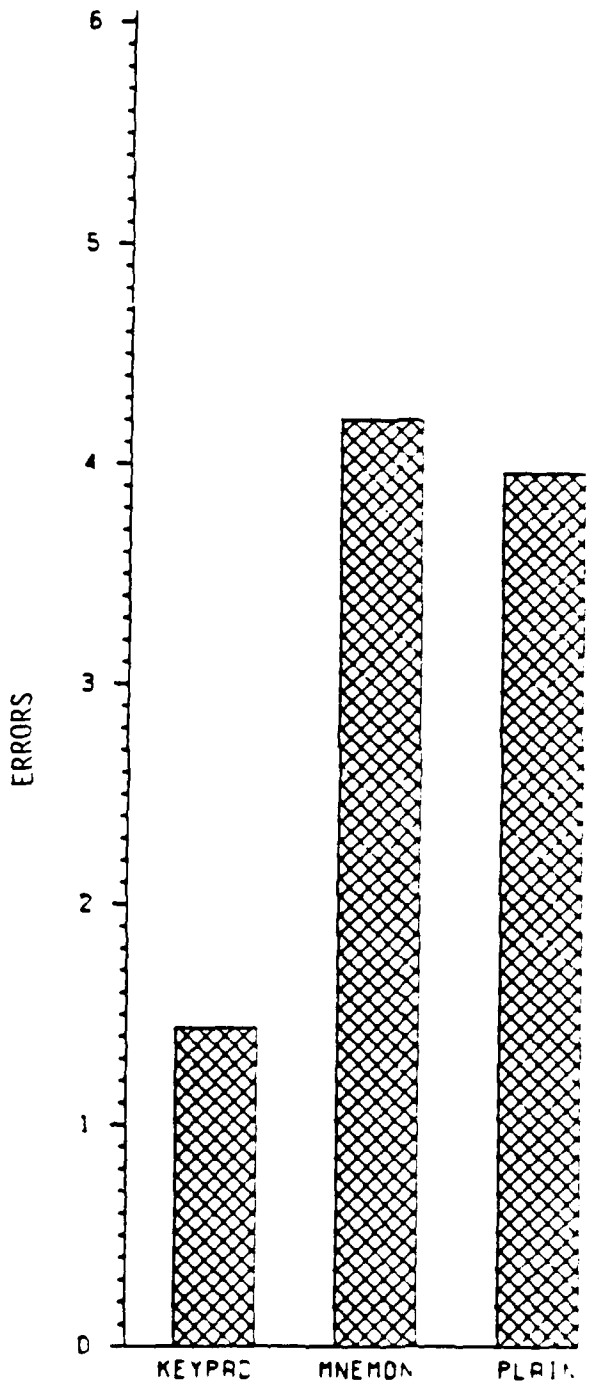


Figure 22
Comparison of Mean Errors Between Conditions
on Number Tests

A number of other follow-up studies and related studies are suggested by the research documented here. Starting with the results of the QWERTY skills test which was used for classification of research participants into groups, but was otherwise unused in the final analysis, a study should be done to investigate transfer effects between the conventional typewriter and different types of chord keyboards. The question of whether skill on a QWERTY board or the manual dexterity involved has an effect on beginner chord users can be investigated using skilled typists and accomplished pianists.

Due to the limited amount of time at the keyboard that volunteers were willing to endure, asymptotic behavior was not reached although a plateau to speed was. A longer study using longer practice sessions, a longer span of days or both should be done to establish a learning curve for both keyboards, the upper limits to speed, and if the chord keyboard actually meets performance claims made by the manufacturer. Research participants for this study would have to have some external motivation greater than the intrinsic rewards available in this study.

The effects of different activation force curves for the keys and different key technologies, different curvatures of the palm rest and even an adjustable palm rest should all be investigated to make the chord keyboard more acceptable to the novice user. Retention of skill over weeks or even months for relatively long time users would make another good study.

The use of various operator populations also lends itself to study. The chord keyboard has been integrated into control columns of certain aircraft for in-flight data entry. Keying ability under workload or stress, with gloves, and in various acceleration environments such as those found in military aviation should be investigated with chord keyboards.

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APPENDIX A

COPY OF TEXT USED FOR TYPING TEST

Exercise 161

	Strokes
From the common-sense standpoint, everyone understands, or considers	68
that he understands, what is meant by time or duration; but an appreciation	143
of its real nature, with its assumed infinite duration in the past and its	217
infinity in the future, has always baffled the philosopher. According to	290
Newton, absolute, true and mathematical time, by itself, flows uniformly	362
on without respect to anything external. He thus conceived time as some-	435
thing which would continue even if there were no other physical	498
phenomena, no material bodies, and no human being in existence. No	565
method, however, can be imagined whereby such absolute time could be	633
directly measured, and it is clear that for time measurement it is necessary	709
to consider other physical changes in addition to time itself.	771
The change with which time can be most conveniently associated for this	842
purpose is motion, and time-measurement is based upon the observation of	914
a standard uniform motion, the rotation of the earth on its axis being that	989
actually employed.	1007
The theory of relativity, with which Einstein's name is associated, has	1078
for long attracted considerable attention, and it includes an idea of time	1152
quite different from that enunciated by Newton. According to this theory,	1226
there is no universal absolute time, and the measurements of both time and	1300
length will vary with the motion of the observer making the measurements.	1373
Two observers on different moving systems will fail to agree as to what	1444
constitutes equal periods of time or equal lengths of bodies, and they will	1519
not always agree as to whether two events occur simultaneously or otherwise	1594
even after adjustments have been made for the time taken by light to travel	1669
from the observed bodies to the observers. Measurements of the velocity of	1744
light, however, give the same result for both observers. The differences	1817
between the measurements of time and length by the two observers are	1885
wholly inappreciable for motions relative to one another which come within	1959
the range of human experience, and no practical difficulties, in connection	2034
with clocks and watches, arise from this theory.	2082
The rotation of the earth, upon which practical time measurement is	2149
based, is determined by the apparent motions of the heavenly bodies, and	2221
some acquaintance with astronomical principles is necessary to appreciate	2293
the methods employed.	2314
Although the stars are at different distances from the earth, they can all	2388
be imagined as projected upon a sphere of which the earth forms the centre.	2463
	493 words

APPENDIX B

ALL PROGRAMS USED IN EXPERIMENT

TEST.MAIN

```
10  DIM A$(25),A1$(25),A2$(25),A3
    $(25),A4$(25)
20 RD =  - 16384:CL =  - 16368
30 D$ =  CHR$ (13) +  CHR$ (4)
40  TEXT : HOME : VTAB 8
50  PRINT "[1] ENTRY OF DATA"
60  PRINT "[2] EDITING OF DATA"
70  PRINT
80  PRINT "[3] TESTING PROCESS"
90  PRINT "[4] PRACTICE SESSION"
100  PRINT
110  PRINT "[5] PRINT DATA"
120  PRINT "[6] PRINT RESULTS"
130  PRINT
140  PRINT "[7] EXIT TO SYSTEM PR
    OMPT"
150  VTAB 20
160  PRINT "PLEASE CHOOSE (1-7) :
    ";
170  GET Z$: PRINT Z$
180  IF  VAL (Z$) < 1 OR  VAL (Z$
    ) > 7 THEN 40
190  ON  VAL (Z$) GOTO 220,200,48
    0,210,600,790,1340
200  PRINT D$;"RUN TEST.EDIT"
210  PRINT D$;"RUN TEST.PRACTICE"

220  REM
```

ENTRY OF DATA

```
230  GOSUB 1540
240  HOME : VTAB 5: HTAB 11
250  PRINT "PLEASE INPUT DATA"
260  VTAB 8
270  FOR X = 1 TO 12
280  PRINT  SPC( (X < 10));X;". "
    ;
290  INPUT "";A$(X)
300  NEXT X
310  FOR X = 13 TO 25
320  VTAB X - 5: HTAB 20
330  PRINT X;". ";
340  INPUT "";A$(X)
350  NEXT X
```

```
360  ONERR  GOTO 1460
370  PRINT D$;"OPEN "TS$",L20"
380  PRINT D$;"READ "TS$",R0"
390  INPUT REC
400  FOR X = 1 TO 25
410  PRINT D$;"WRITE "TS$",R";REC
      + X
420  PRINT A$(X)
430  NEXT X
440  PRINT D$;"WRITE "TS$",R0"
450  PRINT REC + 25
460  PRINT D$;"CLOSE "TS$
470  GOTO 40
480  REM
```

TESTING PROCESS

```
490  HOME
500  VTAB 12
510  PRINT "1. TEST WITH KEYBOARD
     "
520  PRINT "2. TEST WITH MICROWRI
     TER"
530  PRINT
540  PRINT "PLEASE CHOOSE (1/2) :
     ";
550  GET Z$: PRINT Z$
560  IF  VAL (Z$) < 1 OR  VAL (Z$
     ) > 4 THEN 490
570  ON  VAL (Z$) GOTO 580,590
580  PRINT D$;"RUN TEST.KEYBOARD"

590  PRINT D$;"RUN TEST.MICRO"
600  REM
```

PRINT DATA

```
610  HOME
620  GOSUB 1540
630  VTAB 12
640  INPUT "PRINTER SLOT :";PR
650  PRINT D$;"PR#";PR
660  PRINT D$;"OPEN "TS$",L20"
670  PRINT D$;"READ "TS$",R0"
680  INPUT REC
690  FOR X = 1 TO REC
700  PRINT D$;"READ "TS$",R";X
```

```
710  INPUT A$
720  PRINT  SPC( (X < 10));X;".";
     A$;
730  IF PR = 0 THEN  FOR C = 1 TO
     500: NEXT C
740  NEXT X
750  PRINT D$;"CLOSE "TS$
760  PRINT D$;"PR#0"
770  PRINT : PRINT "PLEASE PRESS
     ANY KEY TO CONTINUE";: WAIT
     RD,128: POKE CL,0
780  GOTO 40
790  REM
```

PRINT RESULTS

```
800  HOME
810  VTAB 12
820  INPUT "PRINTER SLOT :";PR
822  PRINT "PRINT ONE FILE OR ALL
      (1/A) :";
824  GET Q$: PRINT Q$
826  IF Q$ <  > "1" AND Q$ <  > "
     A" THEN  VTAB 13: GOTO 822
828  IF Q$ = "1" THEN 1332
830  DIM TS$(255)
840  PRINT D$;"OPEN TEST.RESULTS"

850  PRINT D$;"READ TEST.RESULTS"

860  ONERR  GOTO 900
870 X = X + 1
880  INPUT TS$(X)
890  GOTO 870
900  POKE 216,0
910  PRINT D$;"CLOSE TEST.RESULTS
     "
920  FOR NUM = 1 TO X - 1
930  PRINT D$;"OPEN "TS$(NUM)
940  PRINT D$;"READ "TS$(NUM)
950  INPUT N1$: INPUT N2$: INPUT
     N3$
960  INPUT NMBR
970  FOR Z = 1 TO NMBR
980  INPUT A1$(Z),A2$(Z),A3$(Z),A
     4$(Z)
990  NEXT Z
1000  PRINT D$;"CLOSE "TS$(NUM)
1010  PRINT D$;"PR#";PR
1020  PRINT  SPC( 40 - ( LEN (N1$
```

```
     ) / 2));N1$
1030  PRINT  SPC( 40 - ( LEN (N2$
     ) / 2));N2$
1040  PRINT  SPC( 40 - ( LEN (N3$
     ) / 2));N3$
1050  PRINT
1060  FOR Z = 1 TO NMBR STEP 5
1070  PRINT A1$(Z);
1080  FOR Q = 2 TO 5
1090  PRINT  SPC( 16 -  LEN (A1$(
     Q + Z - 2)));A1$(Q + Z - 1);

1100  NEXT Q
1110  PRINT
1120  PRINT A2$(Z);
1130  FOR Q = 2 TO 5
1140  PRINT  SPC( 16 -  LEN (A2$(
     Q + Z - 2)));A2$(Q + Z - 1);

1150  NEXT Q
1160  PRINT
1170  PRINT A3$(Z);
1180  FOR Q = 2 TO 5
1190  PRINT  SPC( 16 -  LEN (A3$(
     Q + Z - 2)));A3$(Q + Z - 1);

1200  NEXT Q
1210  PRINT
1220  PRINT A4$(Z);
1230  FOR Q = 2 TO 5
1240  PRINT  SPC( 16 -  LEN (A4$(
     Q + Z - 2)));A4$(Q + Z - 1);

1250  NEXT Q
1260  PRINT : PRINT
1270  NEXT Z
1280  PRINT : PRINT
1290  FOR Q = 1 TO 79: PRINT "-";
     : NEXT Q
1300  PRINT
1310  PRINT D$;"PR#0"
1320  NEXT NUM
1330  GOTO 40
1332  REM
          PRINT ONE

1333  HOME : VTAB 12
1334  INPUT "PRINT WHO? :";T$$(1)

1336  ONERR  GOTO 1339
1337 NUM = 1:X = 2
1338  GOTO 920
```

```
1339  HOME : VTAB 12: PRINT TS$(1
      )" IS NOT ON FILE PLEASE": PRIN
      "CHECK SPELLING AND TRY AGAI
      N": VTAB 23: INVERSE : PRINT
      "PRESS ANY KEY TO CONTINUE":
       NORMAL : WAIT  - 16384,128:
       POKE  - 16368,0: POKE 216,0
      : GOTO 40
1340  REM

          EXIT TO SYSTEM


1350  HOME
1360  VTAB 8
1370  PRINT "**********************
      **********************"
1380  PRINT "*
                          *"
1390  PRINT "*                PROGR
      AM BY                 *"
1400  PRINT "*                BRIAN S.
       PLOTKIN              *"
1410  PRINT "*                (C)  04-
      10-85                 *"
1420  PRINT "*
                          *"
1430  PRINT "**********************
      **********************"
1440  NEW
1450  END
1460  REM

          OPEN NEW DATA

1470  PRINT D$;"OPEN "TS$",L20"
1480  PRINT D$;"WRITE "TS$",R0"
1490  PRINT 0
1500  PRINT D$;"CLOSE "TS$
1510  POKE 216,0
1520 REC = 0
1530  GOTO 370
1540  HOME : VTAB 12
1550  PRINT
1560  INPUT "CREATE/USE DATA SET
      # :";DT
1570 TS$ = "TEST.DATA" +  STR$ (D
      T)
1580  HOME
1590  RETURN
```

TEST.EDIT

```
10  ONERR  GOTO 800
20 D$ =  CHR$ (13) +  CHR$ (4)
30  TEXT : HOME
40  VTAB 12
50  PRINT "1) LIST DATA"
60  PRINT "2) EDIT DATA"
70  PRINT "3) RETURN TO MAIN MENU
    "
80  PRINT : PRINT
90  PRINT "CHOOSE 1-3 :";
100  GET A$
110  PRINT A$
120 A =  VAL (A$)
130  IF A < 1 OR A > 3 THEN 30
140  ON A GOTO 150,330,630
150  REM
```

LIST DATA

```
160  GOSUB 730
170  HOME
180  VTAB 12
190  INPUT "PRINTER SLOT :";PR
200  PRINT D$;"PR#";PR
210  PRINT D$;"OPEN ";TS$;",L20"
220  PRINT D$;"READ ";TS$;",R0"
230  INPUT REC
240  FOR A = 1 TO REC
250  PRINT D$;"READ ";TS$;",R";A
260  INPUT A$
270  PRINT A". "A$;
280  NEXT A
290  PRINT D$;"PR#0"
300  PRINT D$;"CLOSE ";TS$
310  GOSUB 660
320  GOTO 30
330  REM
```

EDIT DATA

```
340  GOSUB 730
350  HOME
360  VTAB 12
370  INPUT "EDIT DATA # :";ED
380  PRINT D$;"OPEN ";TS$;",L20"
390  PRINT D$;"READ ";TS$;",R";ED
```

```
400  INPUT A$
410  PRINT D$;"CLOSE ";TS$
420  HOME
430  VTAB 12
440  PRINT "DATA CURRENTLY IS :";
     A$
450  INPUT "CHANGE TO          :";
     B$
460  VTAB 16
470  PRINT "CHANGE ";A$;" TO ";B$
     " ? (Y/N) :";
480  GET Q$
490  PRINT
500  IF Q$ <  > "Y" AND Q$ <  > "
     N" THEN 460
510  IF Q$ <  > "Y" THEN 560
520  PRINT D$;"OPEN ";TS$;",L20"
530  PRINT D$;"WRITE ";TS$;",R";E
     0
540  PRINT B$
550  PRINT D$;"CLOSE  ";TS$
560  HOME
570  VTAB 12
580  PRINT "EDIT ANOTHER ? ";
590  GET Q$
600  IF Q$ <  > "Y" AND Q$ <  > "
     N" THEN 560
610  IF Q$ = "N" THEN 30
620  GOTO 350
630  REM

          RUN MAIN MENU


640  PRINT D$;"RUN TEST.MAIN"
650  REM

          SUBROUTINES


660  VTAB 23
670  INVERSE
680  PRINT "PRESS ANY KEY TO CON
     INUE"
690  WAIT  - 16384,128
700  POKE  - 16368,0
710  NORMAL
720  RETURN
```

```
730  HOME
740  VTAB 12
750  INPUT "USE DATA SET # :";A$
760  PRINT
770  HOME : VTAB 12
780 TS$ = "TEST.DATA" + A$
790  RETURN
800  REM
```

ERROR

```
810  HOME
820  VTAB 12
830  PRINT "YOU MUST FIRST ENTER
     THE DATA!"
840  FOR X = 1 TO 1500: NEXT X
850  POKE 216,0
860  GOTO 630
```

TEST.MICRO

```
1  HOME : IF  PEEK (768) = 76 THEN
      CALL 777
2  IF  PEEK (768) = 76 THEN  GOTO
     4
3 D$ =  CHR$ (4): PRINT D$"BLOAD
     B.MILLISECONDS"
4  CALL 768: REM  SET UP INTERRUP
     TS
5 B = 256: HOME : REM  QUESTIONAB
     LE USE OF VAR B
6  HOME
20  TEXT : HOME :SLOT = 2
30 PK =  - 16384
40 D$ =  CHR$ (4):RD = PK:CL = RD
     + 16
50  DIM A$(25),INCR$(25)
70  INPUT "USE DATA SET # :";DT
80 TS$ = "TEST.DATA" +  STR$ (DT)

90  HOME : VTAB 12
100  INPUT "SUBJECT NAME :";N1$
110  INPUT "TESTING DATE :";N2$
120  INPUT "TEST METHOD  :";N3$
130  PRINT D$;"OPEN "TS$",L20"
140  PRINT D$;"READ "TS$",RO"
150  INPUT REC
160  IF REC = 0 THEN 690
170  FOR X = 1 TO REC
180  PRINT D$;"READ "TS$",R"X
190  INPUT A$(X)
200  NEXT X
210  PRINT D$;"CLOSE "TS$
220 X = 1
230  PRINT  CHR$ (4);"IN#2"
240  HOME : VTAB 3: PRINT  SPC( 1
     5);"ENTER DATA"
250  VTAB 4: PRINT  SPC( 15);"NUM
     BER :";X
260  PRINT : PRINT  SPC( 15);"ENT
     ER :";
270  GET T$
300  IF  ASC (T$) < 97 THEN 320
310 T$ =  CHR$ ( ASC (T$) - 32)
320  PRINT T$;
325  CALL 771: REM  RESET COUNT A
     ND STARTS TIMER
330 Q$ = Q$ + T$
350  GET T$
380  IF  ASC (T$) < 97 THEN 400
390 T$ =  CHR$ ( ASC (T$) - 32)
400 Q$ = Q$ + T$
410  PRINT T$;
```

```
420  IF  LEN (Q$) <  LEN (A$(X)) THE
     350
430  PRINT
431  CALL 774: REM  STOP TIMER
432 MS = 0: FOR A = 780 TO 783:MS
      = MS * 8 +  PEEK (A): NEXT

433 C = MS / 1024:S =  INT (C):MS
      = (C - S) * 1000
440  FOR Q = 1 TO  LEN (A$(X))
450  IF  MID$ (Q$,Q,1) <  >  MID$
     (A$(X),Q,1) THEN WR = WR + 1

460  NEXT Q
461 TIME = S + (MS / 1000)
462 TIME = TIME * 1000
463 TIME =  INT (TIME):TIME = TIM
     E / 1000
480 INCR$(X) =  STR$ (WR) +  CHR$
     (13) + Q$ +  CHR$ (13) + A$(
     X) +  CHR$ (13) +  STR$ (TIM
     E) + " sec"
490 X = X + 1
500 Q$ = "":TIME = 0:WR = 0
510  IF X <  = REC THEN 240
511 SLOT = 4
530 TT$ = "TEST.RESULTS"
540  PRINT D$;"APPEND "TT$
550  PRINT D$;"WRITE "TT$
560  PRINT N1$
570  PRINT D$;"CLOSE "TT$
580  PRINT D$;"OPEN "N1$
590  PRINT D$;"WRITE "N1$
600  PRINT N1$: PRINT N2$: PRINT
     N3$: PRINT REC
610  FOR X = 1 TO 25
620  PRINT INCR$(X)
630  NEXT X
640  PRINT D$;"CLOSE "N1$
650  GOTO 720
660  PRINT D$;"OPEN "TT$
670  POKE 216,0
680  GOTO 550
690  HOME : VTAB 12
700  PRINT "YOU MUST HAVE FIRST E
     NTERED THE DATA    TO BE TES
     TED!!"
710  FOR X = 1 TO 1000: NEXT X
720  PRINT D$;"IN#0"
730  PRINT D$;"RUN TEST.MAIN"
```

TEST.PRACTICE

```
10  TEXT : HOME
20  PRINT "PRESS CTRL-OPEN APPLE-
     RESET TO EXIT"
30  POKE 34,1
40 SLOT = 2
50  ONERR  GOTO 120
60  PRINT  CHR$ (4);"IN#";SLOT
70  GET A$
80  IF A$ =  CHR$ (3) THEN 120
90  IF A$ =  CHR$ (8) THEN  PRINT
      CHR$ (8);" ";
100  PRINT A$;
110  GOTO 70
120  PRINT  CHR$ (4);"IN#0"
130  PRINT  CHR$ (4);"PR#0"
140  POKE 216,0
150  TEXT
160  PRINT  CHR$ (4);"RUN TEST.MA
     IN"
```

```
1  HOME : IF  PEEK (768) = 76 THEN
      CALL 777
2  IF  PEEK (768) = 76 THEN  GOTO
     4
3 D$ =  CHR$ (4): PRINT D$"BLOAD
     B.MILLISECONDS"
4  CALL 768: REM  SET UP INTERRUP
     TS
5 B = 256
6  HOME
20 D$ =  CHR$ (4):RD =  - 16384:C
     L =  - 16368
30  DIM A$(25),INCR$(25)
40  HOME : VTAB 12
50  INPUT "USE DATA SET # :";DT
60 TS$ = "TEST.DATA" +  STR$ (DT)

70  ONERR  GOTO 720
80  GOSUB 760
90  HOME
100  VTAB 12
110  INPUT "SUBJECT NAME :";N1$
120  INPUT "TESTING DATE :";N2$
130  INPUT "TEST METHOD  :";N3$
140  PRINT D$;"OPEN "TS$",L20"
150  PRINT D$;"READ "TS$",RO"
160  INPUT REC
170  IF REC = 0 THEN 720
180  FOR X = 1 TO 25
190  PRINT D$;"READ "TS$",R"X
200  INPUT A$(X)
210  NEXT X
220  PRINT D$;"CLOSE "TS$
230 X = 1
240  HOME : VTAB 3: PRINT  SPC( 1
     5);"ENTER DATA"
250  VTAB 4: PRINT  SPC( 15);"NUM
     BER :";X
260  IF  PEEK (RD) < 127 THEN 260

270 Q1$ =  CHR$ ( PEEK (RD) - 128
     )
280  IF Q1$ =  CHR$ (13) THEN 450

290  POKE CL,0
300  CALL 771: REM  START COUNTER

310  IF  PEEK (RD) < 127 THEN 310
```

```
320 Q =  VAL (Q1$):Q1$ =  CHR$ ( PEEK
     (RD) - 128): POKE CL,0
330  GOSUB 880
340  VTAB 12: HTAB 12: PRINT Q$
350  IF  PEEK (RD) < 127 THEN 350

360 Q1$ =  CHR$ ( PEEK (RD) - 128
     ): POKE CL,0
370  IF Q1$ =  CHR$ (13) THEN 450

380  IF  PEEK (RD) < 127 THEN 380

390 Q =  VAL (Q1$):Q1$ =  CHR$ ( PEEK
     (RD) - 128): POKE CL,0
400  GOSUB 880
410  VTAB 12: HTAB 12: PRINT Q$
420  IF  LEN (Q$) =  LEN (A$(X)) THEN
     450
440  GOTO 350
450  POKE CL,0
455  CALL 774: REM  STOP TIMER
460 MS = 0: FOR A = 780 TO 783:MS
      = MS * B +  PEEK (A): NEXT

461 C = MS / 1024:S =  INT (C):MS
      = (C - S) * 1000
462 TIME = S + (MS / 1000)
463 TIME = TIME * 1000
464 TIME =  INT (TIME):TIME = TIM
     E / 1000
470  FOR Z = 1 TO  LEN (A$(X))
480  IF  MID$ (A$(X),Z,1) <  >  MID$
     (Q$,Z,1) THEN WR = WR + 1
490  NEXT Z
500 INCR$(X) =  STR$ (WR) +  CHR$
     (13) + Q$ +  CHR$ (13) + A$(
     X) +  CHR$ (13) +  STR$ (TIM
     E) + " sec"
510 WR = 0:TIME = 0:Q$ = ""
520 X = X + 1
530  IF X > REC THEN 550
540  GOTO 240
550  ONERR  GOTO 690
560 TT$ = "TEST.RESULTS"
570  PRINT D$;"APPEND "TT$
580  PRINT D$;"WRITE "TT$
590  PRINT N1$
600  PRINT D$;"CLOSE "TT$
610  PRINT D$;"OPEN ";N1$
620  PRINT D$;"WRITE ";N1$
630  PRINT N1$: PRINT N2$: PRINT
     N3$: PRINT REC
```

```
640  FOR X = 1 TO 25
     [illegible]
650  NEXT X
670  PRINT D$;"CLOSE ";N1$
680  GOTO 750
690  PRINT D$;"OPEN "T1$
700  POKE 216,0
710  GOTO 580
720  HOME : VTAB 12
730  PRINT "YOU MUST HAVE FIRST E
     NTERED THE DATA    TO BE TES
     TED!!"
740  FOR X = 1 TO 1000: NEXT X
750  PRINT D$;"RUN TEST.MAIN"
760  REM
```

DATA VARIABLES

```
770 Z$(1) = "STU"
780 Z$(2) = "VWX"
790 Z$(3) = "Y Z"
800 Z$(4) = "JKL"
810 Z$(5) = "MNO"
820 Z$(6) = "PQR"
830 Z$(7) = "ABC"
840 Z$(8) = "DEF"
850 Z$(9) = "GHI"
860  RETURN
870  REM
```

SUB-SPLITTING

```
880  IF Q1$ = "0" THEN Q$ = Q$ +
      LEFT$ (Z$(Q),1)
890  IF Q1$ = "," THEN Q$ = Q$ +
      MID$ (Z$(Q),2,1)
900  IF Q1$ = "." THEN Q$ = Q$ +
      RIGHT$ (Z$(Q),1)
910  RETURN
```

APPENDIX C
INFORMED CONSENT FORM

INSTRUMENT TO OBTAIN INFORMED CONSENT

I, _____, have been informed by Mr. Sheldon A. Wolstein that I have been selected to participate in a study concerning the learning and use of a new single-handed keyboard and the use of a 4x4 numeric keypad.

1. I have been given an explanation of the procedures to be followed, including an identification of those which are experimental.

2. I have been given a description of the attendent discomforts and risks, which include keying in data on both types of keyboards which is presented by a cassette tape player.

3. I have been given a description of the benefits to be expected.

4. I have been given a description of appropriate alternative procedures that would be advantageous to me.

5. I have been offered an answer to any inquiries concerning the procedures.

6. I have been instructed that I am free to withdraw my consent and to discontinue my participation in the project or activity at any time.

7. I have been assured that steps will be taken to ensure confidentiality of the results.

8. I understand that in the event of physical injury resulting from the research procedures described to me that there will be no financial compensation or free medical treatment offered to me.

9. I have not been requested to waive or release the institution, its agents or sponsors from liability for the negligence of its agents or employees.

I, the undersigned, have understood the above explanations and give my consent to my voluntary participation in Mr. Sheldon Wolstein's research project.

_____
Signature of subject

Date: _____

Location: _____

Principal Investigator: Sheldon A. Wolstein
1211 University Oaks, C.S., TX
(409) 696-7519

Another Contact Person: Dr. Rodger Koppa
Texas Transportation Institute
Human Factors Division, C.S., TX
(409) 845-2521

APPENDIX D

TRAINING MATERIAL FOR MNEMONIC CONDITION

Thank you again for agreeing to participate in this study.

The purpose of this part of the study is to teach you how to use the Microwriter keyboard.

If you have any questions please don't hesitate to ask.

ABOUT THE MICROWRITER

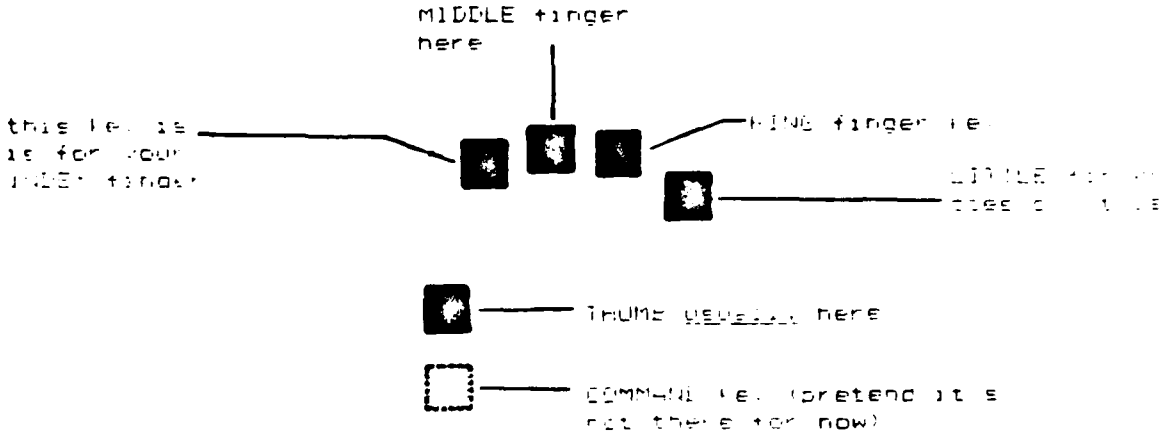
The Microwriter is a relatively new device, developed by an American film director living in England, Cy Enfield. The company marketing the device is called Microwriter LTD., and is wholly owned by Matrix Life Assurance Co. which is a large insurance firm from England.

Microwriter is known as a single hand, six key, handprint chord keyboard. That it is single hand operation on six keys is obvious. "Handprint" means that the keys are laid out so the hand rests naturally on the keys as opposed to having the keys in a 2 X 3 matrix. "Chord" refers to the fact that generally more than one key must be struck to produce a character, similar to piano chords.

THINGS YOU NEED TO KNOW FIRST

It's not like a conventional keyboard. There are only 5 keys on the **MAIN KEYBOARD** plus the **"COMMAND KEY"** (which we won't need for a while so try to ignore it)

Here is a picture of the keyboard, showing where each finger of your right hand is supposed to go.



Now there is a very important point:

DON'T wave your fingers about on the keys or use them on any key other than the one they're supposed to use (as shown on the chart above).

This one-finger-to-one-key correspondence will make the Microwriter easier to use. Microwriting is using one or more keys together at the same time to produce one letter, number, punctuation mark, etc. The important thing to remember at this stage is that using the wrong finger or the wrong key will slow down your learning and lead to lots of mistakes.

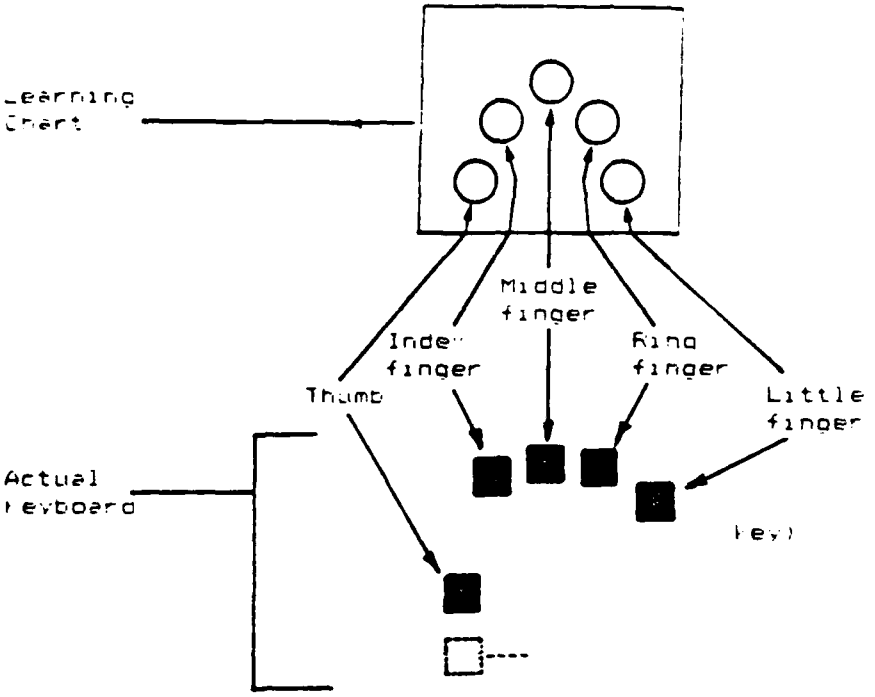
Also, once you start, you'll notice a couple of things about the keys themselves which make them different from the conventional typewriter. First, the keys are very touch-sensitive, much lighter than on a typewriter. This helps you to get very fast, but does mean that you'll make mistakes to begin with. Second, the letters you type are not created when the keys are pressed but instead they are generated when the keys are released. This means that you don't have to get all the keys down at the same instant, just so long as all of the necessary keys get pressed.

Take a little time now, with the machine off, to get acquainted with it and to get used to the feel of the keys and the positions of the fingers. Get into the habit now of keeping each finger on its own key and your thumb normally on the UPPER of the 2 thumb keys.

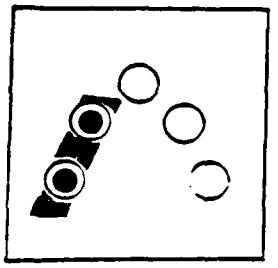
One note about the lower thumb key, the COMMAND key. If you press it by accident, different characters will be produced. If you notice that the incorrect characters are being produced by the correct chord, just press both thumb keys together to clear it.

HOW TO FORM THE LETTERS

It will all be based on this chart:



This chart will show which keys are to be depressed for each character. For example, the letter "I"



The darkened circles correspond to the keys which must be pushed for that letter.

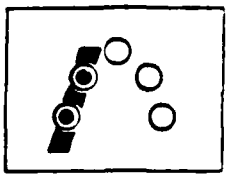
Please do not turn the page

If you have any questions so far, please ask them now. If not, inform Sheldon that you are ready to begin.

You will notice that in the example "I", the keys pressed can be related to the shape of the handwritten letter.

This is how you handwrite the letter "I"

You Microwrite the letter "I" like this, creating the shapes with your finger tips.

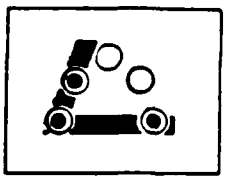


This is a memory aid to help you learn the alphabet. All the letters will have this.

The "L" works the same way:

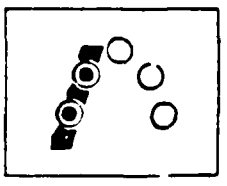
This is how you handwrite the letter "L"

You Microwrite the letter "L" like this

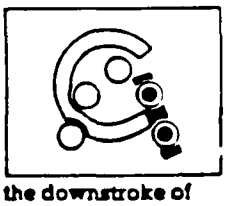


You'll find that a lot of the letters form natural pairs of opposites based on the SHAPES, which can be thought of as "mirror images". Try to remember the letters as these pairs: it's easier. For instance, the opposites of the two you've done so far are "G" and "J":

J

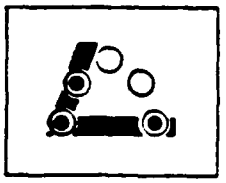


C

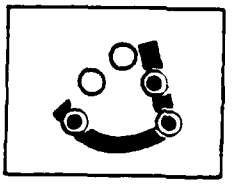


the downstroke of the "C"

L

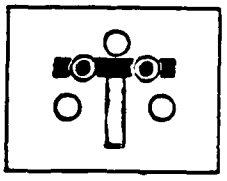


J

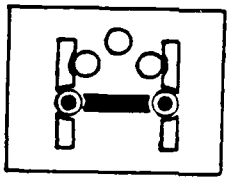


Here is a useful pair to remember as a pair: they're used together so often:

T



H

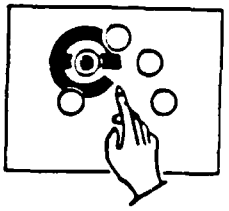


The Top of the "T"

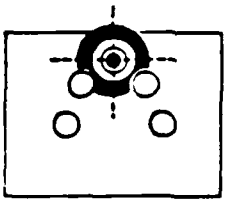
Horizontal for "H"

These are written using only ONE key:

E



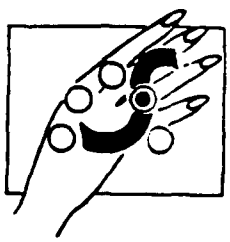
O



Easiest finger for E

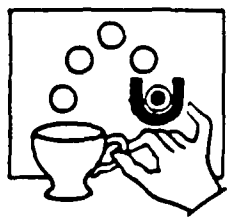
in the middle:looks like a target

S



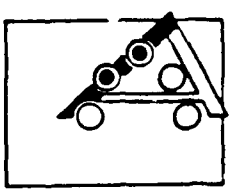
Signet ring finger for "S"

U



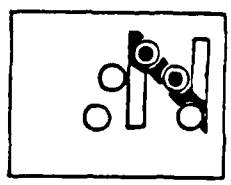
Little finger: very "U"

A



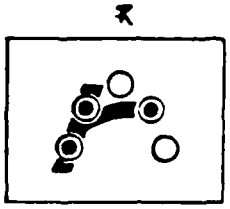
Line to Apex of "A"

N



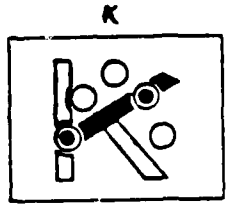
dowN linNe of "N"

R



shape of small "R"

K



Upstroke of the "K"

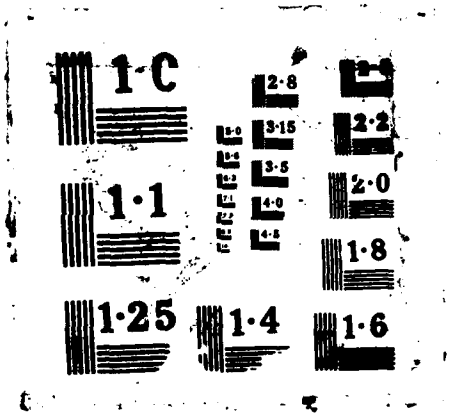
Make any mistakes yet? Don't worry, just continue on, but remember accuracy first, speed later.

You've just covered half of the alphabet. Here's the rest:

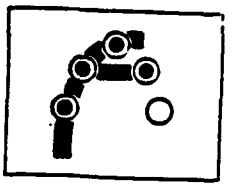
AD-A185 420 AN EXPERIMENTAL STUDY OF A SIX KEY HANDPRINT CHORD KEYBOARD(U) TEXAS TRANSPORTATION INST COLLEGE STATION S A WALSTEIN MAY 86 RF-7053-2I DAAA15-86-K-0010 2/2

UNCLASSIFIED F/G 12/6 NL

END

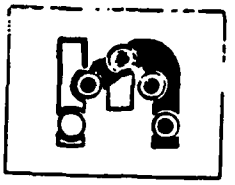

1·C
1·1
1·25
1·4
2·8
3·15
3·5
4·0
4·5
2·2
2·0
1·8
1·6

F



opposites

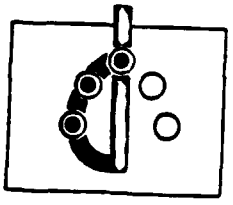
M



First Four Fingers For "F"

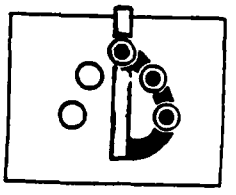
Most fingers Make "M"

D



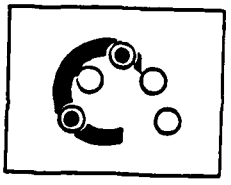
Dome of the "D"

B

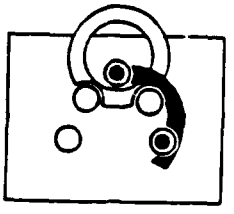


Back of the "B"

C



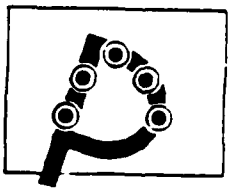
opposites



Curl round for "C"

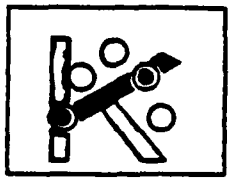
Make the tail from the centre.

P

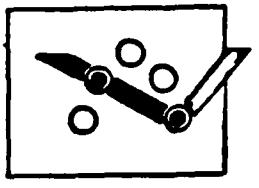


complete Press for "P

K



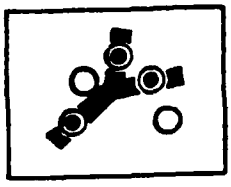
V



the upstroke of the "K"

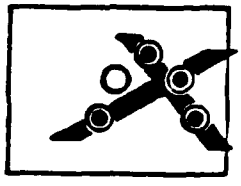
downstroke of the "V"

Y



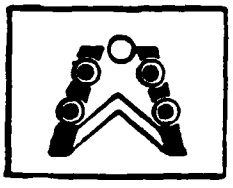
looks like a "Y"

X



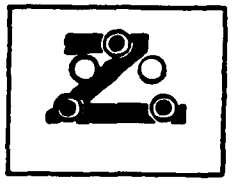
All Xcept your indeX

W



The two sides of the "W"

Z



Zig Zag between the keys

Now if you want to practice some writing, try an old standard:

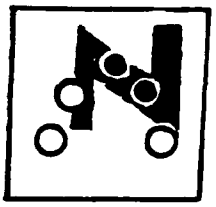
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG

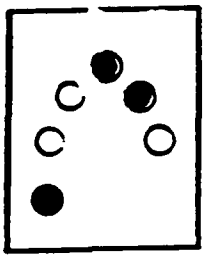
Don't forget to use the cue card if necessary.

Now try:

THE ZEAL OF THE ARCHITECT WAS BEING EXCERCISED CONTINUALLY IN CONJUCTION WITH A KEEN QUANTITY SURVEYOR IN THE DESIGN OF QUAINT BUT PRETTY MAISONETTES.

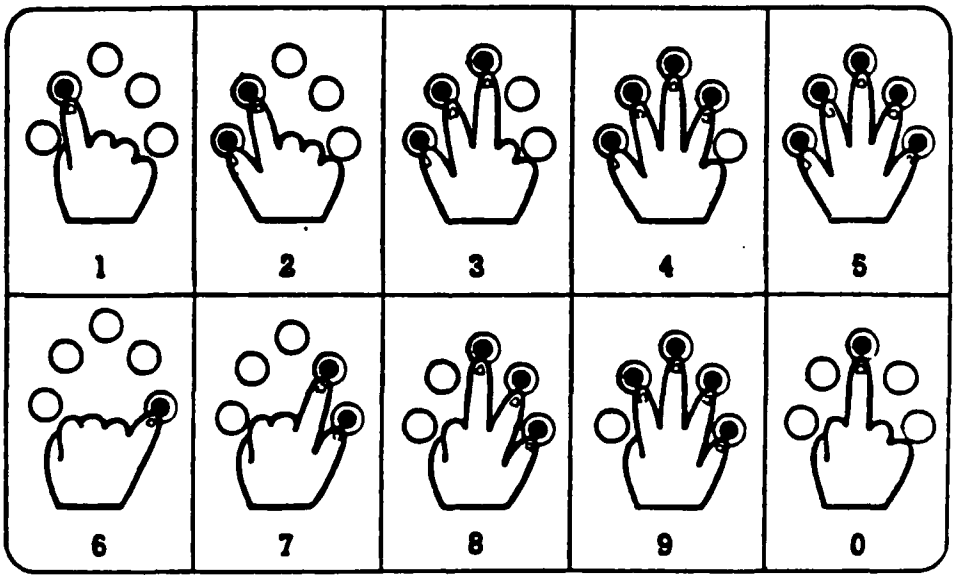
Now you're ready for numbers. If you recall, we mentioned only briefly the command key and how to clear it. Now we have to use it to get to the numbers. To change to the mode which has the numbers you press the command key and the chord for the letter "N" (for "N"umber).





Pressing the command "N" once will make the next regular letter you type a number, then the Microwriter will automatically shift back into the alphabet mode. If you have more than one number in a row to type you should lock into the number mode by pressing the command "N" twice. Type the line of numbers and when you have another letter to type, shift back to the alphabet mode by pressing both thumb keys at the same time.

Here are the numbers. Go ahead and lock the machine into the number mode and practice some.



That's all you have to learn. Now for the practice sessions to gain speed. Remember at first you should concentrate on accuracy, with speed secondary. After a while you should be able to increase your speed without increasing errors.

APPENDIX E

TRAINING MATERIAL FOR PLAIN CONDITION

Thank you again for agreeing to participate in this study.

The purpose of this part of the study is to teach you how to use the Microwriter keyboard.

If you have any questions please don't hesitate to ask.

ABOUT THE MICROWRITER

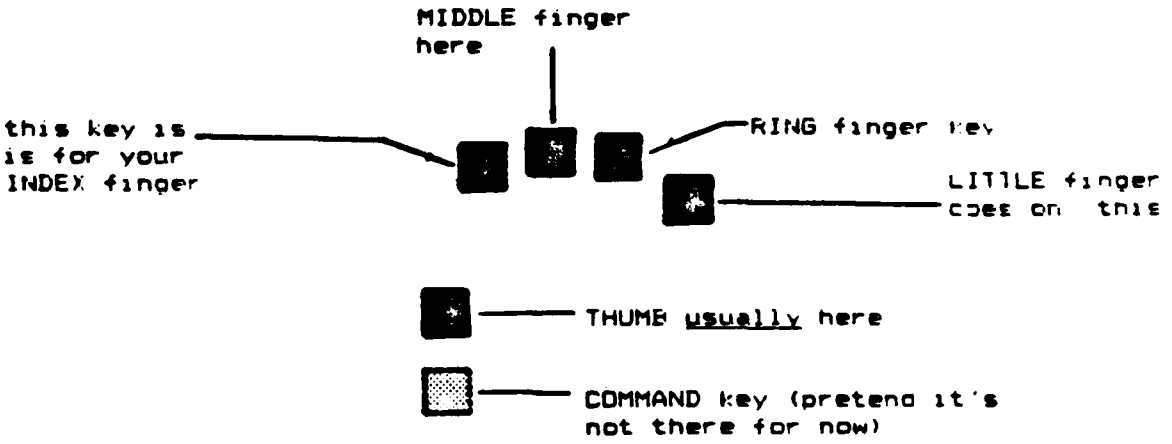
The Microwriter is a relatively new device, developed by an American film director living in England, Cy Enfield. The company marketing the device is called Microwriter LTD., and is wholly owned by Hambro Life Assurance Co. which is a large insurance firm from England.

Microwriter is known as a single hand, six key, handprint chord keyboard. That it is single hand operation on six keys is obvious. "Handprint" means that the keys are laid out so the hand rests naturally on the keys as opposed to having the keys in a 2 X 3 matrix. "Chord" refers to the fact that generally more than one key must be struck to produce a character, similar to piano chords.

THINGS YOU NEED TO KNOW FIRST

It's not like a conventional keyboard. There are only 5 keys on the MAIN KEYBOARD plus the "COMMAND KEY" (which we won't need for a while so try to ignore it)

Here is a picture of the keyboard, showing where each finger on your right hand is supposed to go.



Now there is a very important rule:
DON'T wave your fingers about on the keys or use them on any key other than the one they're supposed to use (as shown on the chart above).

This one-finger-to-one-key correspondence is what makes the Microwriter so easy to use. Microwriting is using one OR MORE keys together at the same time to produce one letter, number, punctuation mark, etc. The important thing to remember at this stage is that using the wrong finger on the wrong key will slow down your learning and lead to lots of mistakes.

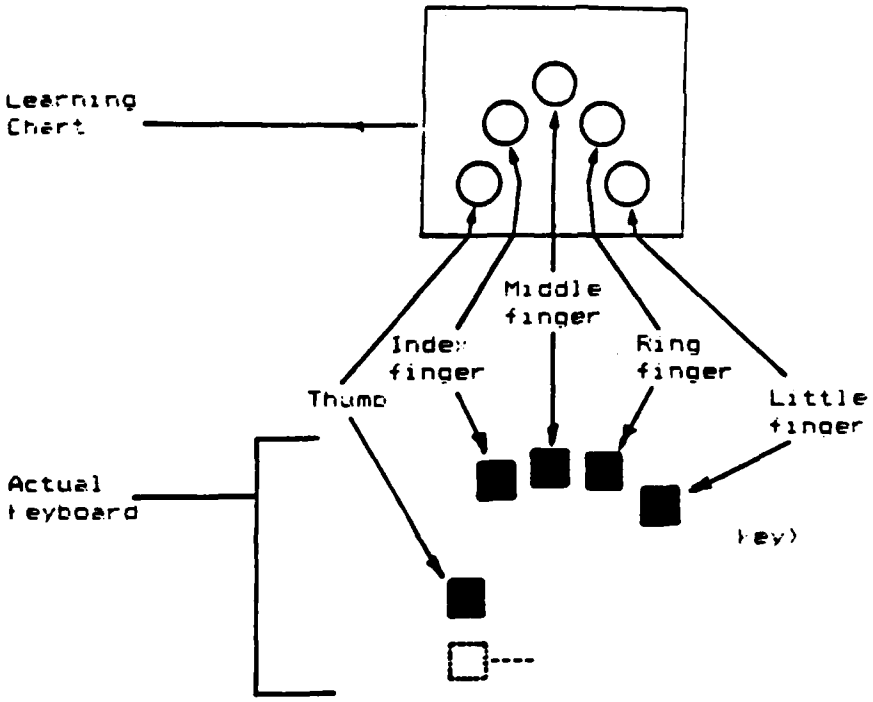
Also, once you start, you'll notice a couple of things about the keys themselves which make them different from the conventional typewriter. First, the keys are very touch-sensitive, much lighter than on a typewriter. This helps you to get very fast, but does mean that you'll make mistakes to begin with. Second, the letters you type are not created when the keys are pressed but instead they are generated when the keys are released. This means that you don't have to get all the keys down at the same instant, just so long as all of the necessary keys get pressed.

Take a little time now, with the machine off, to get acquainted with it and to get used to the feel of the keys and the positions of the fingers. Get into the habit now of keeping each finger on its own key and your thumb normally on the UPPER of the 2 thumb keys.

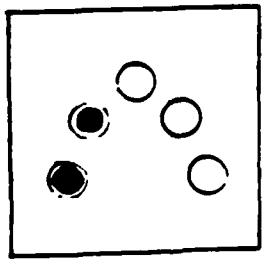
One note about the lower thumb key, the COMMAND key. If you press it by accident, different characters will be produced. If you notice that the incorrect characters are being produced by the correct chord, just press both thumb keys together to clear it.

HOW TO FORM THE LETTERS

It will all be based on this chart:



This chart will show which keys are to be depressed for each character. For example, the letter "l"

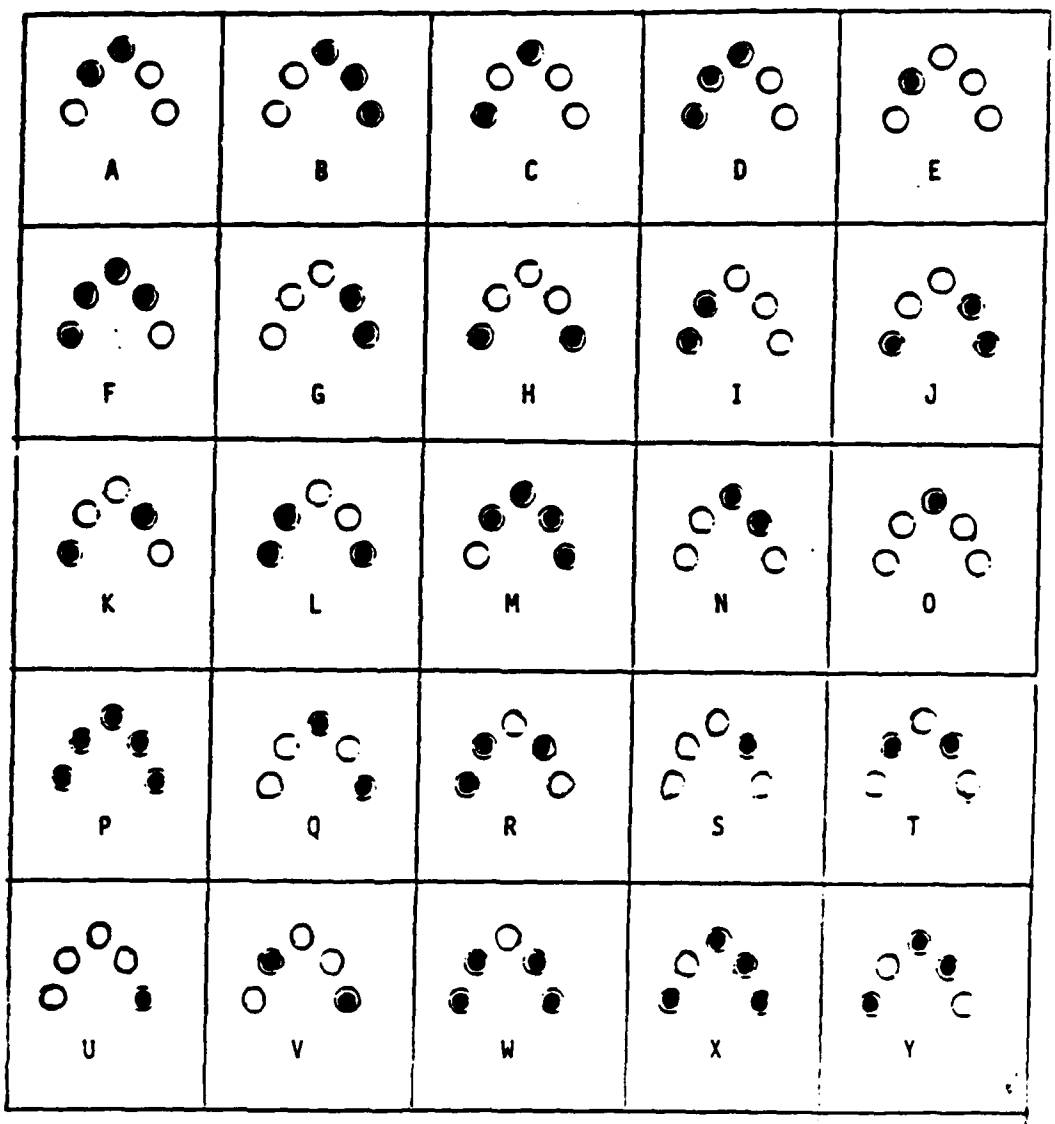


The darkened circles correspond to the keys which must be pressed for that letter.

Please do not turn the page

If you have any questions so far, please ask them now. If not, inform Sheldon that you are ready to begin.

These are the letter chords. Please feel free to practice as you go along.



Now if you want to practice some writing, try an old standard:

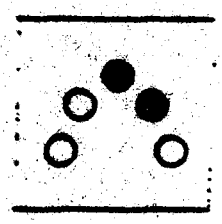
THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG

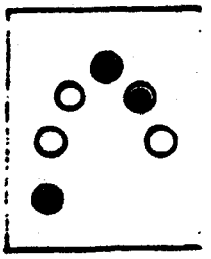
Don't forget to use the cue card if necessary.

Now to

THE [illegible] OF THE [illegible] WAS BEING EXERCISED CONTINUALLY IN [illegible] WITH [illegible] SURFACE OF IN THE DESIGN OF QUAINT BUT [illegible] [illegible].

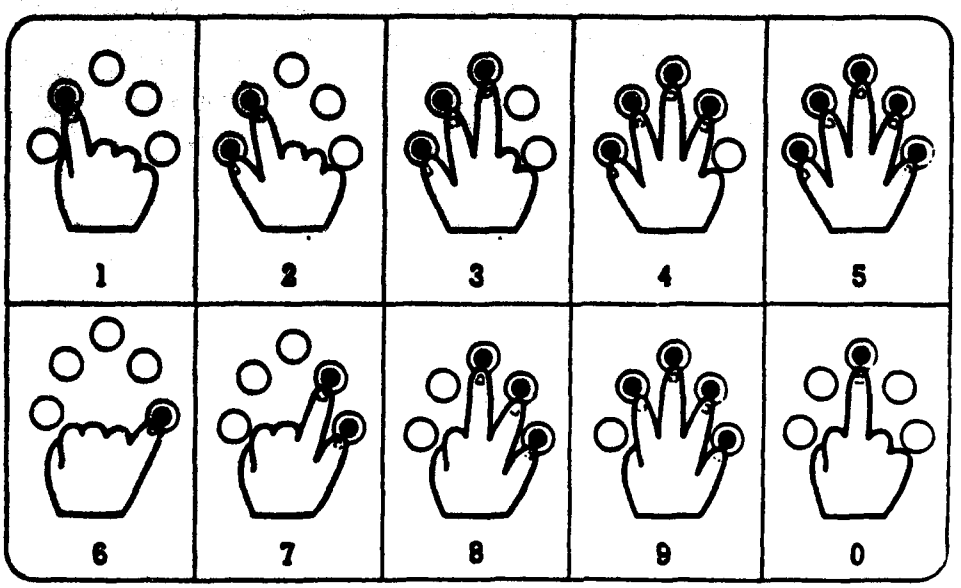
Now you're ready for numbers. If you recall, we mentioned only briefly the command key and how to clear it. Now we have to use it to get to the numbers. To change to the mode which has the numbers you press the command key and the chord for the letter "N" (for "N"umber).





Pressing the command "N" once will make the next regular letter you type a number, then the Microwriter will automatically shift back into the alphabet mode. If you have more than one number in a row to type you should lock into the number mode by pressing the command "N" twice. Type the line of numbers and when you have another letter to type, shift back to the alphabet mode by pressing both thumb keys at the same time.

Here are the numbers. Go ahead and lock the machine into the number mode and practice some.



That's all you have to learn. Now for the practice sessions to gain speed. Remember at first you should concentrate on accuracy, with speed secondary. After a while you should be able to increase your speed without increasing errors.

APPENDIX F

TRAINING MATERIAL FOR KEYPAD CONDITION

Thank you again for agreeing to participate in this study. The keyboard you will be using is a standard 4x4 numeric keypad with a few buttons changed. As you can see, on either side of the "0" there are two arrow buttons. These are to be used in entering the alphabet.

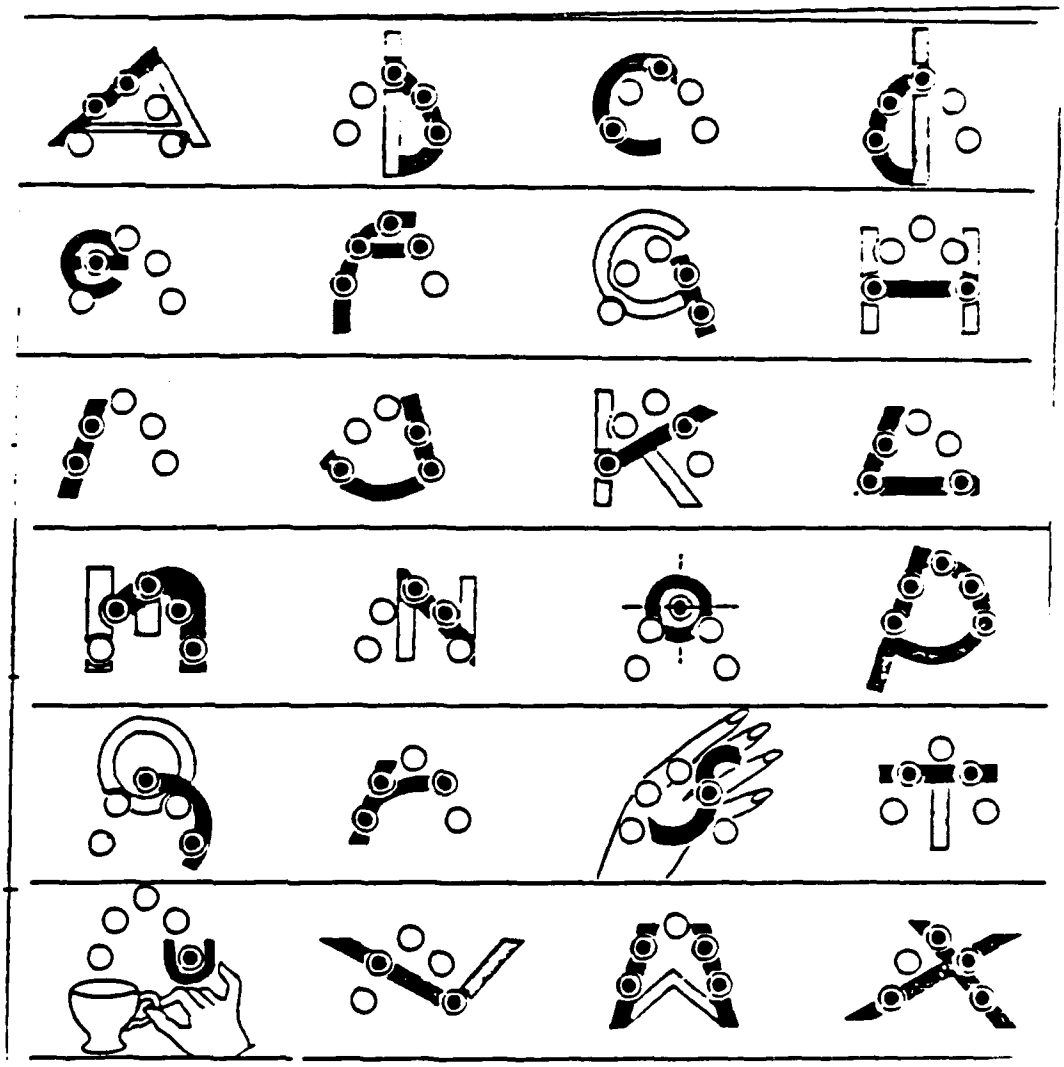
When you need to enter a letter, locate it on one of the regular number keys. Press the key with the desired letter and then press either of the arrows or the "0" to show which of the letters is chosen. For instance the letter "M" would be chosen by pressing the "6" key and then the left pointing arrow "<----".

That's all there is to it. First there will be a timed run to see how well you can do without any practice, then some practice tasks and at the end of the hour another timed run. Ask any questions now. If you have no questions, please let Sheldon know you're ready.

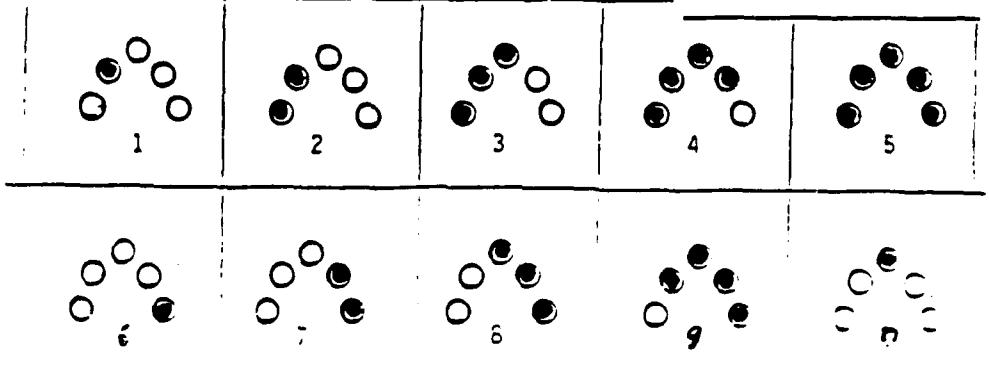
APPENDIX G

ONE SHEET CUE CARDS FOR MICROWRITER

Mnemonic Condition

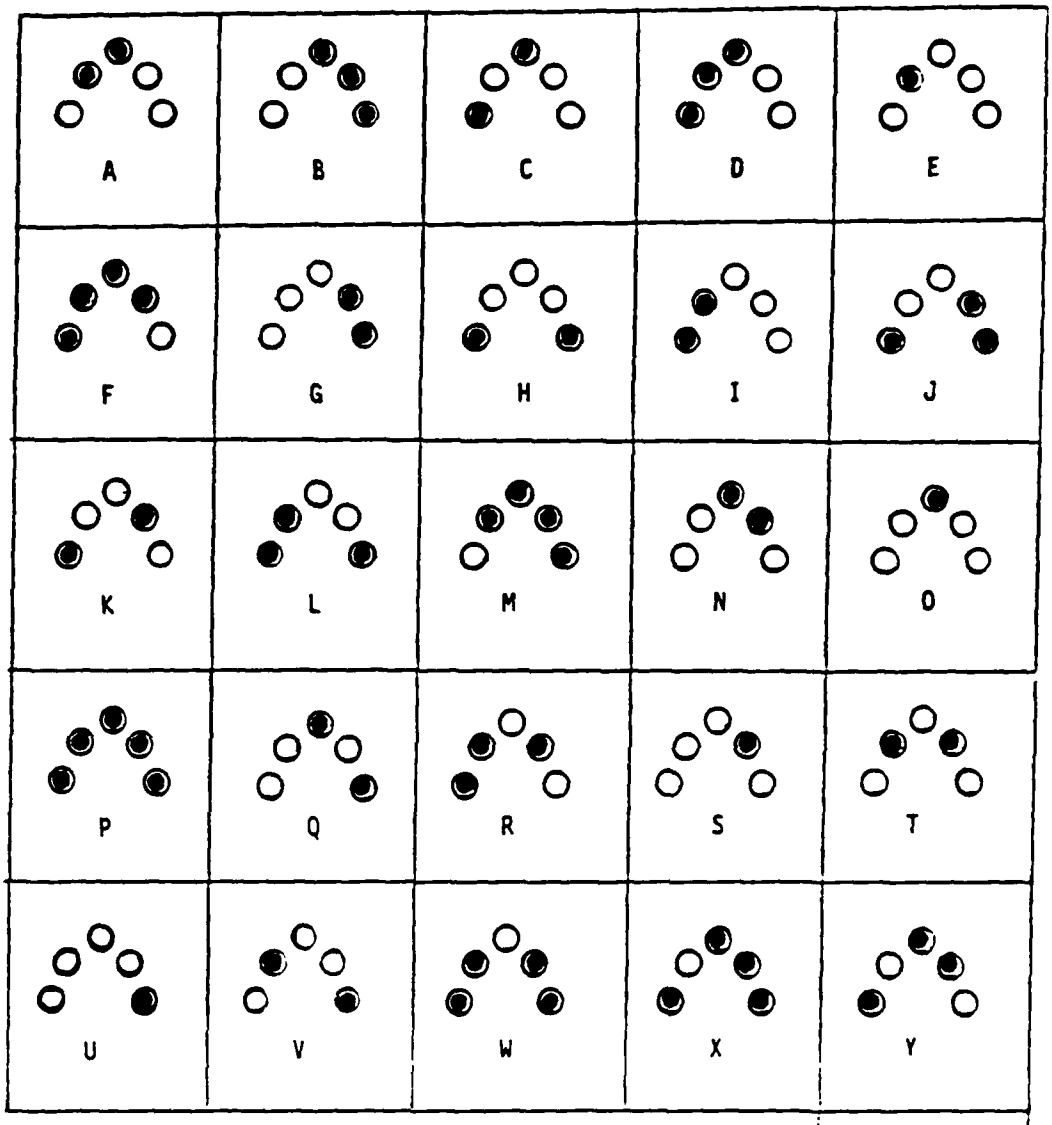


NUMBERS

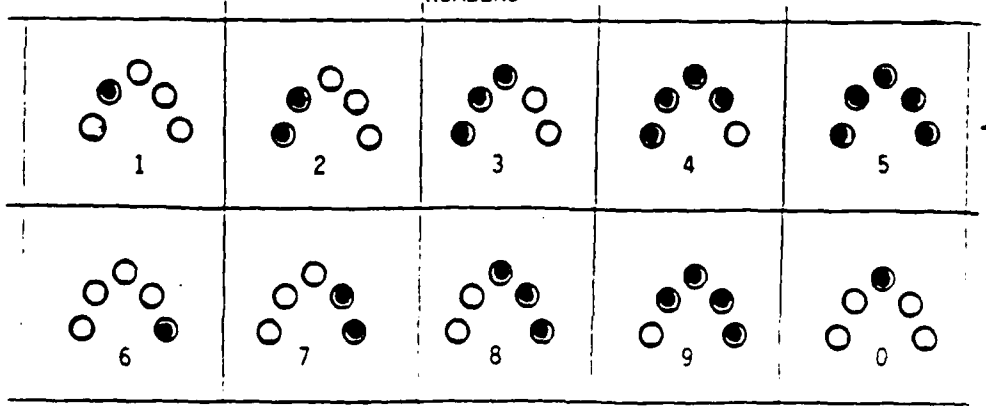


Plain Condition

These are the letter chords. Please feel free to practice as you go along.



NUMBERS



APPENDIX H

EXAMPLE OF PRACTICE ARTICLE

Barrons reports that earlier this year major financial institutuions invested large amounts in airlines. Leading the air lines in the top 50 net purchases lists was Delta Air Lines, with 321.6 million of shares purchased, 202.7 million sold with 117.9 million as the net transaction from a holding of 1218.0

For the picture of the high tech companies refer to the chart below, all amounts in millions of dollars:

STOCK	PURCHASES	SALES	HOLDINGS
McDon Doug.	288.8	110.8	1188.4
Matsushi. Elec.	163.5	17.9	379.5
Viacom	181.2	57.9	420.4
Xerox	286.9	164.5	2435.7
Tandy	272.5	151.8	1377.?
Martin Marietta	229.1	121.5	1059.?
ITT	355.5	250.8	1721.0
E Systems	172.?	71.4	380.7
Boeing	504.6	406.1	3613.7

For other companys' stock, activity was also brisk. Disney shares of 293.6 were bought, 118.4 were sold, and a holding of 887.5 was reported. For McDonalds bought were 350.6, sold were 252.3, and a holding of 3335.2. Reporting institutions also sold 20.6, bought 125.2, and held 311.4 of Dillards Stores stock.

On the down side where these institutions sold off more than they purchased of a particular company s stock were such blue chips as Phillips Petroleum with 920.5 million, Eastman Kodak with 558.1 and 141.6 of Atlantic Richfield. Also dumped were 234.6 million of IBM, 153.7 of Ford, and 66.4 of Coca-Cola.

Overall, the biggest groups bought up were electric power with 1340.9 million in net purchases, drugs with 835.8, air transport with 686.7, and 677.4 worth of entertainment companies. The biggest sales were in hotels and motels with 386.1 million in net sales, foods with 352.3, 288.1 in natural gas pipe and 268.4 in radio-tv broadcasting. Computers, business machines, semiconductors, and electronic equipment which are facing the same slowdown in their shared market when combined accounted for 414.5 million in net sales.

END

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